DISCOVERY

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DISCOVERY

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Michelangelo Improved Upon

THE MODERN SUBMARINE   URANIUM SOURCES IN DEVON

(*for full list of contents see page iii*)

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Stretches of Time

THE earth is about 3,000,000,000 years old. Many of the stars appear to be thousands of times older still (though, by some methods of calculation, the age of the universe has a habit of coming out less than the age of the earth). Nevertheless, three thousand million years is a considerable stretch of time; and for at least two-thirds of that immense period the earth moved through space, as Venus does now, carrying no life of any kind.

Almost by a physico-chemical accident, it seems, life chanced to begin. The conditions that were needed are complex and delicately adjusted: alter the temperature by a few degrees, alter the amount of light or water, and the first living thing would not have been born: leave out the carbon in the earth's envelope, and neither our kind of life nor any other would have been possible—the earth would have swum round in the sunlight, dead for another thousand million years and for ever. It is long odds that, anywhere in the universe, life, used in any sense that we can understand the word, has needed substantially the same conditions as brought it into being on the earth.

That happened several hundred million years ago: about nine-tenths of the earth's present age had already passed before life had begun to flourish in the warm seas under the ammoniacal air. The geological epochs passed: uncounted forms of life died away or developed, some biological failures and others successes. Only one million out of the three thousand million years was left at the time that cunning ape-like creatures began to occur in families scattered here and there about the world.

So the genus *Homo* did not exist until relatively near to our own days. Those first members were not of our own species: *Homo siniensis*, who lived in Mongolia nearly a million years ago, was not a direct ancestor. Perhaps our real ancestors were a little more cunning. Perhaps they were more predatory and fierce.

For very nearly the whole million years since the genus came into existence, its members lived precariously, fearfully, from hand to mouth. True men of 50,000 years ago, such as those of Cro-Magnon, probably were our equals in innate gifts: no one has seen the world more vividly and directly than the artists who painted the caves of Altamira. But they had not found the trick of growing food regularly, so that they could stay in one spot and keep themselves comfortably alive. They were sometimes starved, sometimes overfed, often unoccupied and lazy.

It was not until quite recently—recently, that is, among these great wastes of time—that men learned to grow food with the seasons. Agriculture seems to have been discovered in the Abyssinian hills, perhaps ten to twenty thousand years ago. The lives of those engaged in it became more rather than less arduous: the lives of all but a tiny fraction of the millions who have lived since have been unthinkably arduous, monotonous and unrelieved; the great peasant masses of the world have nothing of the freedom, the leisure, the laziness of the hunters in the first days of the species. But though men lost much by the invention of agriculture, they gained security: with the result that larger groups of men could live together.

With agriculture, civilization was invented, and spread down the great river valleys, first probably in Egypt and then in Mesopotamia. By 10,000–5000 B.C., men were living in large groups: the species, through this conquest of food-growing, was increasing more rapidly than any big animal had ever done before.

And so now man has had, if we take the generous estimate, about 12,000 years of something like civilization. It is not so long, judged by the cosmic figures. It is not even so very long, judged by the history of the species itself. We know, we know too well, that he has not made a success of those 12,000 years. But he has a vast time ahead. Apart from fantastic accidents in the universe, the species has millions of years ahead of it—unless it kills itself first. And somehow it is hard to believe that it will kill itself. Even now, there is a certain bleak comfort about the thought of those millions of years to come. If we can hope for anything, we can put our hope in that sheer stretch of future time.

EDITOR

Oils and Fats in War Time

THE chief varieties of fats under Government control coming into this country, are:

Animal Oils and Fats

Beef tallow
Mutton tallow
Lard
Animal greases

Vegetable Oils

Olive, rape, palm, soya-bean, coconut, sesame, palm kernel, groundnut, cottonseed, linseed, castor

Marine Oils

Fish Whale

(The terms "oil" and "fat" are practically synonymous.)

Of these, only the animal fats, soya-bean oil and some marine oils are produced in this country, and none of them in quantities sufficient to meet the demands of industry. These fats come from widely different sources, and are very different in appearance, but all of them (with the exception of castor oil) are mixtures chiefly of the fatty acids mentioned below, though more unsaturated acids than linoleic occur in the paint oils.

These fats are imported into the country either in the form of the fat itself (palm oil, animal oils, coconut oil, etc.), or in the form of seeds or nuts from which the oil can be extracted by crushing or by the use of solvents (groundnuts, castor seeds, etc.). By relatively simple treatment, these fats can be bleached almost white in most cases, and can, if necessary, have their characteristic odours removed.

The two most important treatments to which fats may be subjected, in order to make them more suitable for a particular industry, are splitting and hydrogenation, and of these hydrogenation (see p. 5) is by far the most important, and one which has been rendered even more important by the war.

"Splitting" a fat means breaking the fat molecule into the two constituents of which it is composed—glycerol and fatty acids. This can be accomplished by a variety of chemical processes. By treating the fat with steam under high pressure in an autoclave, and by subsequently distilling the fatty acids with steam, a split of over 98 % can be obtained, and the fatty acids produced are of good quality. These fatty acids are used in the soap and textile industries. It is important to note that fatty acids are not edible. The substance known as oleine in commerce is made by this process, and is chiefly oleic acid. Similarly stearine is chiefly stearic acid, and this is used almost exclusively in candle manufacture. Fats which contain both oleic acid and stearic acid are treated by compression and filtration at a low temperature, whereby the two components are separated. A really good method of effecting this separation, however, has yet to be found. The glycerol produced as a by-product in this splitting process is important, since it is used in the preparation of nitroglycerine, the explosive.

Chemical Constitution of a Fat

To understand completely the uses to which oils and fats are put it is necessary to have a knowledge of the chemical constitution of a fat. Fats may be regarded as the products of a combination between glycerol ("glycerine") and substances known as fatty acids. The fatty acids are rather a remarkable series of similar related compounds. Each member of the series contains the characteristic acid group —COOH, and attached to this is a

chain of carbon atoms which may vary in length from one up to about twenty-five atoms. Hydrogen atoms are attached to each carbon atom in the chain, and the ratio of carbon to hydrogen in the chain is always such that the number of hydrogen atoms is one more than twice the number of carbon atoms. Thus, for a chain of two carbon atoms, there will be five hydrogen atoms, and for a chain of three carbons, there will be seven hydrogens. The general formula for the chain is thus C_nH_{2n+1}, and for the whole fatty acid $C_nH_{2n+1}.COOH$.

All the members of the series can now be written out. The simplest fatty acid is obviously $CH_3.COOH$, which is acetic acid, and the longest acid is $C_{25}H_{51}.COOH$, which is cerotic acid, a substance present in the wax of the tubercle bacillus. It is on the length of the chain that the characteristic properties of fatty acids, and therefore of fats, depends. Actually, in the natural fats, only a few of the possible fatty acids are used, and these mostly have chain lengths between thirteen and seventeen carbon atoms. One remarkable feature of the fatty acids present in naturally occurring fats is that though chain lengths of thirteen, fifteen and seventeen carbon atoms occur, fatty acids with chains of fourteen, sixteen and eighteen carbon atoms long are entirely absent. This is probably due to the method of fat synthesis adopted by living organisms, the mechanism of which is not fully understood.

The most common fatty acids of this type which are found in natural fats are:

Stearic acid	$C_{17}H_{35}.COOH$
Palmitic acid	$C_{15}H_{31}.COOH$
Myristic acid	$C_{13}H_{27}.COOH$

These are described as "saturated" acids because they have their full complement of hydrogen atoms. All three are solids, but, as the series is descended from stearic acid to myristic acid, the melting point falls slightly, so that while stearic acid is a hard white solid, myristic acid is a slightly softer white solid.

Corresponding to these saturated acids, there are some naturally occurring fatty acids which are described as "unsaturated" because they have not sufficient hydrogen atoms to maintain the ratio of carbon to hydrogen as $n : 2n+1$. The two most important unsaturated acids are:

Oleic acid	$C_{17}H_{33}COOH$
Linoleic acid	$C_{17}H_{31}COOH$

Both of these are the same as stearic acid, except that one has two and the other four hydrogen atoms less. This has a very important influence on the fatty acids and the fats made from them. Stearic acid is a hard solid, but oleic and linoleic acids are both liquids, and so the general effect of the presence of unsaturated acids is to soften a fat. Fats containing high proportions of saturated acids are usually hard solids, while fats which contain chiefly unsaturated acids are soft solids or liquids. This can be illustrated by comparing the amounts of the different fatty acids present in two fats, tallow and olive oil:

	Myristic acid	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid
	%	%	%	%	%
Tallow	6	24	29	41	—
Olive oil	—	7	2	86	5

Tallow contains a high proportion of the solid fatty acids, and so is fairly hard, while olive oil is a liquid because it contains a high proportion of the unsaturated fatty acids.

The result of a combination between glycerol and a fatty acid is known as a glyceride, and fats, therefore, are mixtures of the glycerides of different fatty acids, and may be hard, soft, or liquid, depending on the relative amounts of each fatty acid present.

Such differences in composition account for the slightly different properties of the fats occurring in nature. There are usually other differences such as taste and smell, but these are not due to the fats themselves, but to the presence of small proportions of other substances characteristic of the source of the fat. Tallow, for example, always has a slightly animal smell, and seal oil is usually fishy. These characteristic smells are almost completely destroyed during the refining processes.

Hydrogenation

As its name implies, hydrogenation is the process of adding hydrogen to a fat. Briefly, it can be performed by passing hydrogen through the heated fat in the presence of a catalyst—usually nickel. The value of this process can be seen by a reference to the formulae of the fatty acids. If four atoms of hydrogen are added to linoleic acid ($C_{17}H_{31}.COOH$), the resulting product is stearic acid ($C_{17}H_{35}.COOH$). Similarly, oleic acid ($C_{17}H_{33}.COOH$), by the addition of two atoms of hydrogen, becomes stearic acid. Hydrogenation only affects the unsaturated acids, since the others already have their full complement of hydrogen. Thus the net result of hydrogenating a fat is to transform liquid fats partly or wholly into solid fats—in other words, to harden them. The process is often described as the hardening of fats, for this reason. The following figures illustrate the effect of hydrogenating a sample of palm oil:

	Myristic acid	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid
% composition	%	%	%	%	%
Before hydrogenation	2	32	6	52	8
After hydrogenation	2	32	65	1	—

It will be noticed that the effect has been to convert all the linoleic acid, and almost all the oleic acid, into stearic acid. The result therefore is to change a fat which is soft into one which is hard. In this example, hydrogenation has been carried out almost to the full extent, and the resultant fat would probably be too hard for use in the edible fat industries, but might be suitable for candle manufacture. The hydrogenation process can be interrupted at any stage, and a semi-hydrogenated palm oil would not be as hard as the fully hydrogenated one, and would be suitable for edible purposes.

The Reason for Fat Hardening

Part of the problem in fat hardening is that of trying to suit the traditional demands of English people. Fats which are liquid at ordinary temperatures, such as olive oil, have never been popular in England, though they are used a great deal on the Continent. There is a demand, however, for harder fats, such as frying and shortening fats, suet and margarine, which is an emulsion of water in fat. Hydrogenation makes it possible to satisfy this demand by hardening fats which otherwise would not be regarded as palatable.

Probably the cheapest fats obtainable to-day are the marine oils, such as whale oil, fish oil, etc. They are semi-solid, and usually smell strongly of fish. By hydrogenation, they can be made considerably harder and perfectly white, and they lose their objectionable odour. At one time the characteristic odour of these hardened fats returned after storing for some time, but this difficulty has been overcome, and hardened whale oil is a pure white solid, similar to flaked suet in appearance. It is practically without smell or taste, and is quite pleasant to eat. A good deal of the margarine in use is made from this substance. Unfortunately, the treatment of the fat during the refining and hardening

processes destroys any vitamins present, but during the manufacture of margarine these vitamins are replaced (chiefly vitamins A and D), and the resulting margarine, from a food point of view, is quite as nutritious as butter. Indeed, it is difficult to understand the stigma attached to its use. During the last war, the annual consumption of butter per head fell from 17 lb. to 8 lb., and that of margarine rose correspondingly from 8½ lb. to 17 lb. At the present time, the relative figures per head are: butter 25½ lb. and margarine 9 lb. If the war continues long, these figures may be reversed, and it must be stressed that there should be no adverse effect on the public health if this is so.

Other fats are hardened for edible purposes, most of them being vegetable fats. Cottonseed oil, palm oil, groundnut oil, etc., are all hardened, and are used in margarine and in the manufacture of lard substitutes, frying and shortening fats, etc. The word "substitute" is unfortunate, since chemically a lard substitute might be identical with natural lard and, in any case, it would be quite as valuable as a food.

The Fat-Consuming Industries

The chief industries using fats are the food, soap, and paint and linoleum industries, and smaller consumers are the cosmetic, lubricant and printing-ink industries. It is necessary to consider their special requirements and the effect of the war on the distribution of fats among these industries.

In war-time especially, the food industry is the most important consumer of fats. Fat is a very necessary part of man's food, and the shortage of imported butter and lard makes the provision of substitutes essential. Almost any fat can be hydrogenated to a degree when it would be palatable. This means that some of the imported fats must be diverted from their normal users—chiefly soap-makers—and used for food. At the present time, for example, it is almost impossible for soap-makers to obtain groundnut oils (the oil expressed from "monkey nuts"). Most of it is probably used in the food industry. In general, if more edible fats are required, it is the soap-makers who will go short, but there is a limit to this diversion of fat from its normal users. Fatty acids are inedible, but can be used by soap-makers who are, therefore, the biggest glycerol producers. For a fat to be edible, it must be a glyceride, and the glycerol is in a sense wasted from a war point of view, since it is consumed as food, and not in explosives. This has an effect on the distribution of fats among the various users.

It is interesting to note that soya-bean oil is edible, and is used in Germany. Soya-bean flour is a particularly valuable food, and is part of the ration carried by soldiers. The rapid advance of the German Army through Poland, it has been suggested, was partly due to the value of this food.

The soap industry can use almost any fat except the highly unsaturated ones, such as linseed oil and castor oil. Hydrogenated oils can be used, and hydrogenated fish oil is used in large quantities. Soaps are the sodium salts of fatty acids. Sodium palmitate ($C_{15}H_{31}.COONa$), for example, would be an excellent soap. Briefly, soap-making consists in boiling fats with caustic soda, whereby the glycerol is split off, and the fatty acids converted into soap. This glycerol is separated and concentrated, and is a valuable by-product. Soap-makers can, of course, use the fatty acids resulting from the splitting process, which by simple neutralization with caustic soda give soap. The chief fats used in soap-making are palm oil, tallow, coconut, palm kernel, cottonseed and groundnut oils, and animal oleines.

The demand of the paint and linoleum industries does not encroach on that of any other industry. The paint and linoleum industries require liquid fats which are highly unsaturated. Oleic and linoleic acids are unsaturated acids, and there are more unsaturated acids still, e.g. linolenic acid ($C_{17}H_{29}.COOH$; cf. stearic acid

$C_{17}H_{35}$.COOH). These acids are present in the paint-making oils as glycerides. Linseed, sesame and rape oils are the chief oils used in paint and varnish manufacture. Their use depends on this unsaturation. Highly unsaturated oils have a tendency to polymerize and become thicker, and when spread in a thin layer they become tough resinous films. All the paint oils are imported, and they are used for nothing but the paint and linoleum industries.

Because of the comparative smallness of the demands of the less-important users of fats, the war should not affect them very much. The cosmetics' industry uses olive oil and other liquid fats in face creams. Stearic acid is used in the form of its soap, sodium stearate, as an emulsifying agent in creams, and in the form of its zinc salt in face powders. Fats of the coconut variety are used in shaving creams; these fats are, of course, only required in small quantities.

In lubricating oils and greases, tallow, palm oil, oleine and castor oil may be used, but again the demand is small compared to that of the soap trade. Castor oil deserves a special mention. Its main constituent, ricinoleic acid, is identical with oleic acid except that it has one hydroxyl (—OH) group attached to one of the carbon atoms. This makes castor oil useless as a soap and a food. It is, however, an excellent lubricant, and is also used as a purgative in medicine.

From a consideration of the demands of the various users, it is obvious that the food and the soap industries are the most important consumers. From one point of view it would appear reasonable for the Ministry of Food to divert most of the imported fats into the food industry, and to ration soap. If it were not for the glycerol in fats, this might be done. But, especially in war-time, the country must have a large supply of glycerol available for the manufacture of nitroglycerine. As already noted, the soap industry produces glycerol as a by-product. The edible-fat industry produces no glycerol, and so the supply of fats coming into the country must be shared out with an eye on these two rather conflicting demands. The problem of the Ministry of Food is, therefore, mainly one of distribution.

Consumers of fats in this country have already come under a control scheme. The principle of the control is that no firm should have more fat than the normal requirements necessitate, and that all fats should be diverted to the industries where they will be most useful to the country. Certain fats are exempt from control, and it is probable that this exemption will shortly be extended to other fats. The prices of all fats have been fixed by the Government, and in no case (with the possible exception of linseed oil) do they greatly exceed the prices ruling before the war. At present, there does not appear to be any shortage of fat in the country, and providing submarine warfare is kept under control, there is no reason why the fat-consuming industries should not function as easily as they do in peace-time.

T. K.

"THERE is now a considerable movement on the part of scientific workers, to consider their responsibilities to society at large. It is quite a new urgency. The British, the American, the Australian and other Associations for the advancement of Science, all in the last year or so, have created special divisions for the study and improvement of the relations of the world of research to political and social life; they have set on foot an inquiry into the modernization of education and the wider diffusion of knowledge and I believe it would be of very great mutual advantage if we could bring our assertion of intellectual freedom into a co-operative *liaison* with this awakening of the scientific world republic to the dangers of official interference and misdirection that threaten it. Their cause is our cause."

H. G. WELLS

WHERE DO SEALS LIVE?

by

Dr Colin Bertram

Twenty-seven different species of seals are recognized; most of them live in the polar seas, but some have never seen the sea. Dr Colin Bertram here writes of the distribution of different kinds of seals. The yearly toll of seals killed for all purposes totals three-quarters of a million. A second article by Dr Bertram will be published later.

About three-quarters of a million seals are killed yearly, so that, except for domestic animals, there are more seals killed annually than any other large mammal. Yet general knowledge about seals is very scant. People may have seen what they call seal-skin coats, or watched with delight the antics of sea-lions at the circus, and perhaps have glimpsed a dark head bobbing in the waves off some remote part of the Cornish or Scottish coast, but whether these are different aspects of the same animal few people seem to know. It is therefore interesting to enquire what kinds of seals there are in the world, and to what uses they are put.

In all, there are about twenty-seven species of seals in the world, and these belong to three main groups differing considerably from one another. There are the eared seals (Otariidae) consisting of about ten species, the walruses (Odobaenidae) with two species, and the True seals (Phocidae) with some fifteen species. The members of all three groups are of course well adapted to an aquatic existence, as is recognized by the inclusive term "Pinnipedia", meaning animals with paddle-like feet.

The Eared seals are, however, the least modified of the three groups for aquatic life. Though wonderfully agile in the water, swimming mostly by powerful strokes of the fore-flippers, they can still move actively on land using the legs almost in the normal quadrupedal fashion. The True seals on the other hand have lost much of their original terrestrial mobility. The legs can no longer raise the body clear of the ground, so that the animal must proceed by a series of hitching movements not unlike those of a looper caterpillar. In this movement the fore-limbs, which proportionately are very small, are used simply as props for the

front part of the body, acting in unison rather than alternately. In some species of True seals the fore-limbs in the adult can scarcely touch the ground at all. But they can still be used, when the animal is lying on its back, to scratch its nose. The hind-flippers of the True seals are likewise very different from what they are in land mammals and in the Eared seals. In the True seals the leg bones are still more shortened and the flippers are permanently stretched in a backward direction, consequently being entirely useless for movement on land. In the water the hind-flippers are opposed to one another with the digits spread wide apart, so forming a most effective "tail". Swimming then takes place by powerful lateral undulations of the hind-part of the body just as in a fish. The real tail is a minute appendage a few inches in length extending back between the hind-legs.

As the name implies, the eared seals possess visible external ears, though very small in size. The True seals of course also have ears, but the external trumpet or pinna is minute or wholly absent, and the head presents a smooth unbroken surface. There are many other differences between the two main groups, but these are the chief ones. The walruses are in many respects intermediate between the Eared and True seals. They are characterized by their great bulk and the extraordinary development of the upper canine teeth, which are used to rake up food, clams and other invertebrate animals, from the bottom of the sea.

But the nomenclature of seals is not quite as simple as it seems, for a number of other names are in regular use. There are sea lions, sea bears, sea elephants, sea leopards, fur seals and hair seals, and all these must be fitted into our scheme. Sea elephants and sea leopards are the standard names for two species of True seals that live in the sub-Antarctic and Antarctic regions. Sea lions or hair seals, and sea bears or fur seals, are pairs of synonymous terms for the two divisions into which the group

Weddell Seal. Notice the backward extension of the limbs that is typical of True seals

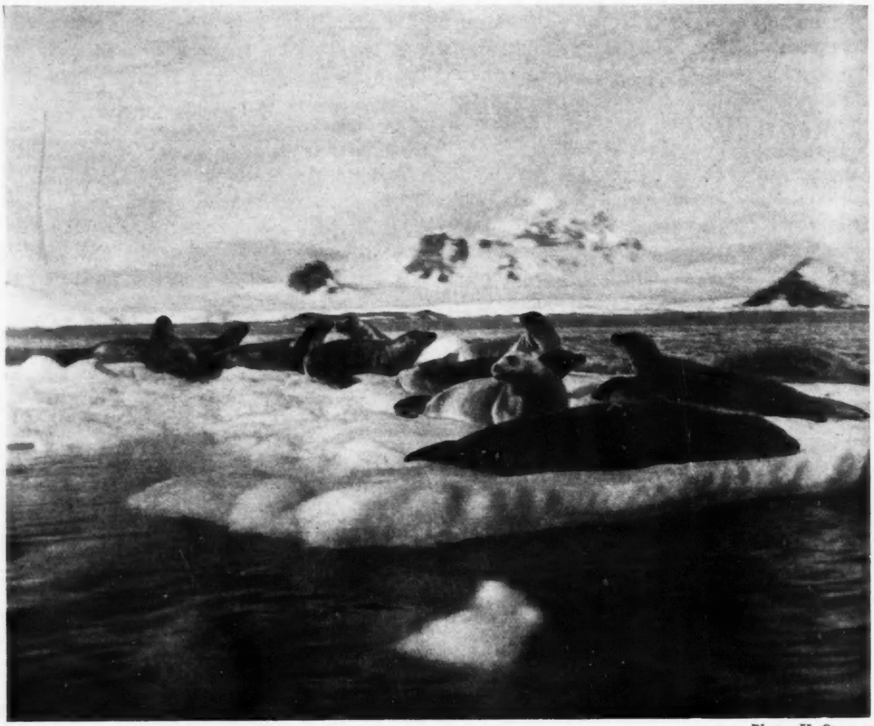


Photo. H. Stevenson

Crab-eater seals on a floe

of Eared seals is conveniently divided, based on the appearance and texture of the coat. The terms in most common use for these two divisions are sea lions and fur seals, the one group providing the acrobatic balancers of the circuses and having a hairy coat, the other being exploited for its rich furry undercoat. Further muddles occur by some people referring to true seals as Hair seals, and in the old days, in New Zealand at least, female sea lions were regularly called sea bears.

Now as to the distribution of the seals, they are not confined to temperate or polar seas as most people suppose. A few of them do not even live in the sea at all. Species closely related to the fjord seal (*Phoca foetida*) of the north, or perhaps only subspecies of it, live in the land-locked Caspian Sea, Lakes Baikal and Oron, and in Lake Ladoga. Living in warm or tropical waters are the three species of monk seals (*Monachus*), one of which inhabits the Mediterranean and Canary Islands, the second living around the West Indies, and the third at the Laysan Islands near Hawaii. All these, however, are now extremely scarce, as is the Californian sea elephant of Guadeloupe Island.

The remainder of the True seals are all animals of temperate or cold waters. There are four species in Antarctic seas, the Weddell, the crab-eater, the leopard and the Ross seal, the last being the rarest of all species, scarcely more than fifty individuals having as yet been seen. Then on

Photo. Brian Roberts

Driving a bull elephant seal backwards to the water's edge

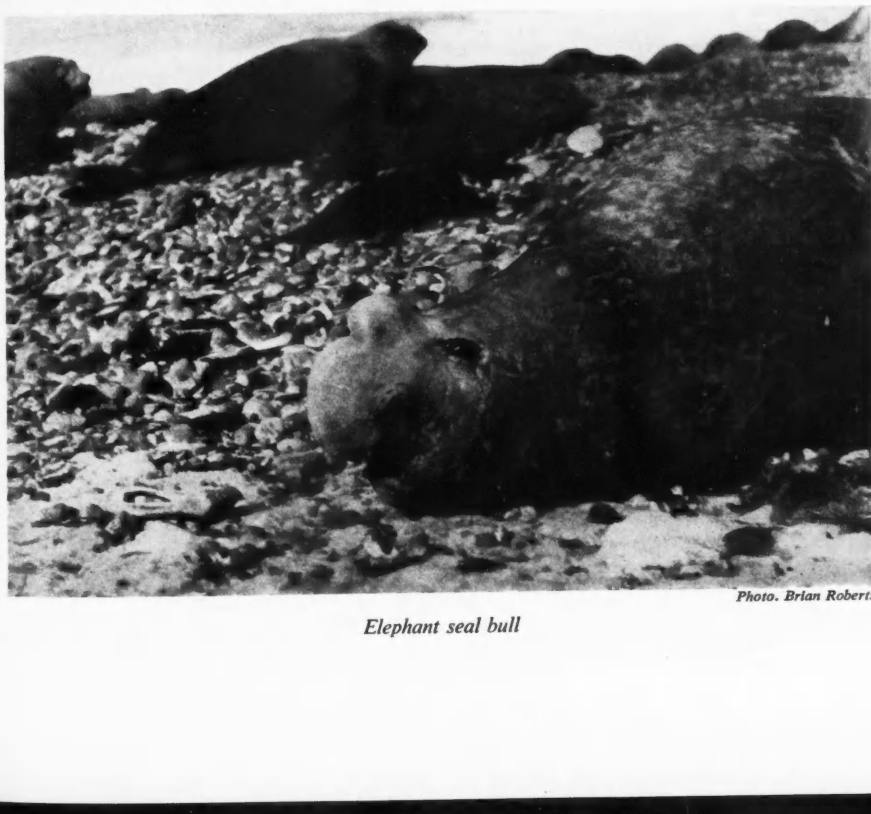
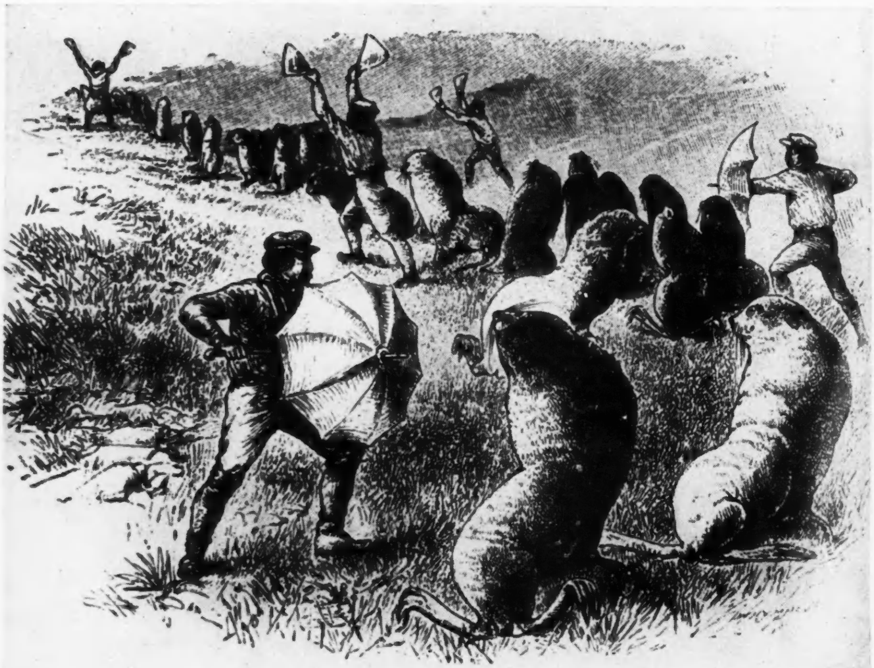


Photo. Brian Roberts

Elephant seal bull

the sub-Antarctic islands there is the southern sea elephant, the largest of all seals, the bulls reaching a length of 20 ft. or even more. All the rest of the True seals live in northern temperate or Arctic seas, several of them being circumpolar in their distribution. The Arctic species are the harp (Greenland or saddleback), the bearded and the bladdernose or hooded seal, the latter in the distensible nature of its nose (in the male only) being related to the sea elephant of the south. In more temperate waters there is the rare banded seal of the north Pacific, the Grey seal and the common seal. The last two species are those that are found around the British Isles, and both occur on the opposite side of the Atlantic in comparable latitudes. Round our islands the Grey seal tends to be confined to the western seaboard from Scilly to North Rona, while the common is the smaller and more typical east coast species.

The two species of walrus are confined, the one to the North Atlantic and adjacent polar seas, the other to the Behring Strait area. The Eared seals are very different from both the two preceding groups in their distribution in the seas of the world. The most remarkable fact is the complete absence of Eared seals from the whole North Atlantic and western Pacific areas. The main home of the various species of eared seals is in the sub-Antarctic zone, round the shores of the isolated islands of the southern ocean. Thence they appear to have spread to the temperate extremities of the southern land-masses, Australia, New Zealand, South Africa and South



Driving three-year-old bulls to the killing grounds. The brightly coloured umbrellas are alternately opened and shut in the face of the seals, to persuade them to move as directed. From H. W. Elliott, 1887

America. In addition they are spread all the way up the western seaboard of the Americas from Tierra del Fuego to Alaska. One species even breeds at the Galapagos Islands right on the equator.

Seal meat is extremely good to eat, and

Seals at South Georgia

Photo. Isobel Hutchinson.
From "Stepping Stones from Alaska to Asia"

Northern Fur Seals

it is much used by polar explorers and is the main diet of many Eskimos. But it is not for the meat that seals are killed commercially. In fact, something in the neighbourhood of 100,000 tons of seal meat are wasted every year, this quantity representing approximately the combined weight of the carcases after the removal of the skins and blubber. Seal blubber is rendered to an oil only slightly different in quality and price from whale oil. The "skins", however, are the most valuable product, taking the world's seal fisheries as a whole.

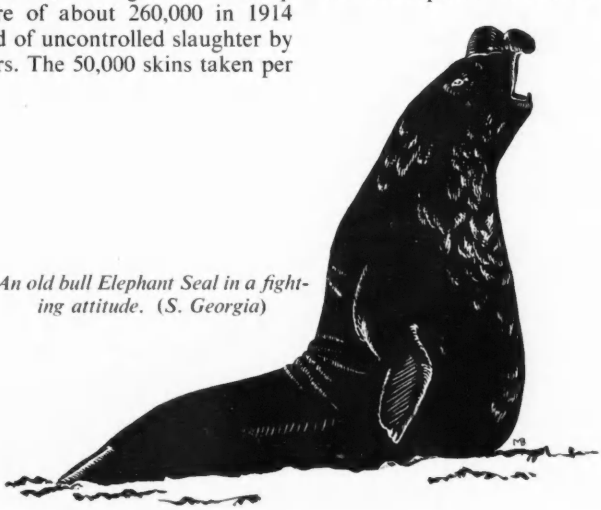
"Skins" may be subdivided into four categories. First of all there is the skin itself which is used for leather coats and many smaller articles, the hair having been completely removed. Then there is what most people mean when they refer to "sealskin", a very fine soft velvety fur which was much more frequently seen in Victorian days as ladies' coats and muffs. This is really the undercoat of the fur seal (an Eared seal), the long stiff guard hairs having been plucked out during the complicated processing that the raw skin must undergo. Next there is the hairy skin of half-grown or adult individuals of various species of True seals. Each hair is straight and stiff, lying flat when wet, slightly upcurled when dry. Such skins, with the hair removed, provide the leather already mentioned. Certain of these skins, like that of the fjord or ringed seal, make very handsome coats. The last of the four categories into which the "skins" may be divided is made up of the beautiful woolly, usually white, coats of the pups of certain species of true seals. The pup is born in this thick woolly coat, but moults it within a very few weeks of birth, replacing it with the hair-type coat of the adult. To obtain the "white coat" the pups must therefore be killed when they are not more than about three weeks old.

The main seal fisheries of the present day are in the North Atlantic and in Behring Strait. Walruses used to be killed in large numbers for their tusks, but now their numbers are seriously depleted. In the fifty years before 1830 the stocks of seals

in the southern ocean had been exploited to such an extent that to-day they are but a shadow of what they once were. Sea elephants were killed for blubber-oil and practically exterminated on all the sub-Antarctic islands. Now they exist in large numbers only at South Georgia where they are under government control, and where nearly 4000 adult bulls are killed per year under licence. The species of southern fur seal which yielded the most valuable skin is now virtually extinct throughout its range due to the depredations of these early sealers. The number of skins taken was immense; it is estimated that 1,200,000 came from South Georgia alone between 1775 and 1822. The slaughter of these seals went on under conditions of incredible waste, the females and pups being killed along with the more valuable males, quite apart from the shiploads of skins that rotted into uselessness before they ever reached civilized ports.

Good quality seal-skins are now only produced to the number of about 50,000 per year at the Pribilof Islands off Alaska, where the herd of northern fur seals is carefully watched over and controlled by the U.S.A. The herd now numbers some 1,800,000 animals, having been built up from a figure of about 260,000 in 1914 after a period of uncontrolled slaughter by pelagic sealers. The 50,000 skins taken per year are those of three-year-old bulls only, animals in which the fur is at its prime. Since the species, like all other Eared seals and the elephant seal, is highly polygamous, the killing of a large proportion of the bulls has no deleterious effect whatever on the breeding stock.

The other main seal fisheries of to-day are in the North Atlantic, and are concerned chiefly with the harp seal and to a much lesser extent with the bladdernose or hooded seal. The harp seals collect together to pup in the early spring in certain well-defined areas on the pack ice, at the mouth of the White Sea, the "West Ice" (near Jan Mayen) and north-east of Newfoundland. The new-born pups or "white-coats" are killed in enormous numbers, and later on, the part-grown seals and adults are taken for their leather and blubber. The toll taken yearly of the North Atlantic harp seals is over half a million, though this figure is far smaller than it was some seventy or eighty years ago. But we have not enough knowledge to state whether or not this toll is greater than the stock can reasonably stand. Detailed knowledge of seals is in fact still very disproportionately small in relation to their importance in the world to-day.



An old bull Elephant Seal in a fighting attitude. (S. Georgia)

A Decimal System for Organisms

By DR G. RABEL

"If Miss Higgledy marries Mr Piggledy, she still remains a member of the Higgledy family and so do her children, even if all of them look like their father. And, if her father dies, without leaving a will, her son, young Piggledy, would be a legal heir, whether or not he resembles his grandfather. If, however, resemblance had been included into the definition of the family, any child that deviated in looks or character from the family type would automatically cease to be a member of this family. And this, however foolish it may sound, is actually what is done in biology."

Dr Rabel, whose work is already familiar to readers of Discovery, *here describes an ingenious system designed to simplify the identification of species.*

IF you try to find out from some book or essay on systematics or from an encyclopaedia, exactly what a species is, you will invariably meet with the statement that this is exceedingly difficult to define. Strongly as systematists otherwise disagree, they are in perfect agreement on one point, namely, that it is entirely arbitrary and subjective which forms should be honoured with the name of separate species and which should be given only the rank of subspecies, or varieties, or geographic races.

Various reasons are set forth to explain the difficulty of a clear-cut classification, one of them being the evolutionary development which constantly creates new species. I think, however, that the dilemma does not entirely spring from the nature of things, but that a great portion of the perplexity connected with the species problem originates in a fundamental confusion which is by no means inevitable.

When we compare the scores of definitions given by different authors, we find that most of them (with few exceptions) run approximately along the lines of the definition formulated more than a hundred years ago by the celebrated French zoologist Cuvier, which says: "A species comprises those individuals which descend from one another or from common ancestors (parents) and those which resemble them as much as they resemble one another."

This definition consists of two parts. One, taking common descent as a basis, is a biological, genetical definition, the other, dealing with resemblance, is of a logical, purely descriptive character. And it is, in my opinion, just this muddle which is the main cause of difficulties and confusion.

It might be suspected that it is only the old age of this definition which makes it so awkward, and I am therefore adding one which is taken from a modern dictionary of philosophical terms. According to this oracle, a species is "a group of genetically related individuals presenting fairly constant and distinctive hereditary characters and sufficiently alike to be included under one name".

The same story: genetically related—and alike.

It is now my duty to explain the different meanings of a logical descriptive definition, and a biological one, to make these concepts quite clear.

The term "species" in itself has nothing to do with living beings. It was used in ancient philosophy with different meanings. One of these meanings was that of a smaller group of things contained in a larger group called genus. Thus, if groups *B*, *C*, *D*, ... are interposed between the widest, the "summum genus", *A*, and the narrowest, the "infima species" *Z*, *B* is called a species when compared to *A*, but a genus when

compared to *C*. Again *C* is a species of *B*, but a genus in relation to *D*, and so forth.

In this relative sense Aristotle used the term genus in his *History of Animals*. He calls reptiles, fishes, and crustaceans genera, and he distinguishes between large genera which comprise again many smaller groups, and simple ones which do not. The crustaceans, for example, contain—again as genera—lobsters, shrimps, and crabs, but the crabs and shrimps, in their turn, include again several genera, such as spectre-crabs and locust-shrimps.

The word "eidos", Latin species, occurs frequently, mostly in the sense of *shape*, sometimes of *kind*, but without implying a definite systematic meaning.

What is first observed by untrained people is the genus not the species. It requires some training and power of observation to distinguish the species within the genus and therefore the present species concept has been introduced rather late into biology. But we do find the so-called binomial nomenclature (e.g. *Ranunculus nemorosus*) in the plant catalogue of Bauhin who lived from 1550 to 1624, and occasionally we find in this catalogue terms like "species lutea".

*   *   *   *

The logical distinction between genus and species can, of course, apply to any objects whatsoever. Thus, for example, the genus Knife may be divided into several species, such as penknife, table knife, bread knife, razor, etc. We might define the penknife as a knife small enough to be carried in the pocket, with foldable, sheathable elements, characterized by the feature that one blade at least is always suitable for sharpening pencils and erasing ink spots. We are quite sure in which features all the members of a certain species agree, notwithstanding possible individual characteristics, say a monogram on one penknife or a corkscrew in another. Under this condition we may ask the question: Do penknives and table knives come from the same stock, i.e. from the same factory? Or do all penknives come from Manchester and all table knives from Birmingham? Or is it perhaps that some penknives and some table knives come from Manchester and others from other places? That may be a silly question to ask, but it is at least clearly formulated; we know exactly what we mean by it, because we know what a penknife is and what a table knife is.

But now suppose we would include in our definition the condition of common descent. We would say, that it is not enough for a penknife to have the features mentioned; in order really to be called a penknife it would have to come from a certain factory. However, unfortunately, we do not know from which factory the knives have come. Should we then know anything at all? Should we know which knives are penknives and which are table knives? Obviously not. That means that the descriptive definition of the species has been blurred by the admixture of a requirement quite foreign to it, that of common descent.

Now, on the other hand, let us take a biological definition, such as that of a human family: a family comprises all individuals which have descended either from one another or from common ancestors. Nothing more. Nothing about resemblance.

If Miss Higgledy marries Mr Piggledy, she still remains a member of the Higgledy family, and so do her children, even if all of them should happen to look like miniature duplicates of their father. And if Mr Higgledy dies without having left a will, and legal heirs are searched for, young Ronald Piggledy would be a legal heir, whether or not he resembles his grandfather.

If, however, we had included resemblance into the definition of the family, any child that deviated in its looks or character from the family type would automatically cease to be a member of this family. And this, however foolish and crazy it may sound, is actually what is done in biology.

A species is considered a group of individuals of common descent. When, however, an individual "mutates", i.e. acquires some new inheritable character, it becomes the founder and ancestor of a new species and is no longer included in the old one. And this event is one form of what is called "the Origin of Species".

As long as species are considered as biological groups, that is, as individuals of common descent, their origin is no problem. Individuals originate by birth, and that is all there is to it. The enquiry after their origin makes sense only when they are taken as logical categories, which means as a combination of features. What Darwin, for example, was really trying to find out, was the manner in which certain features in animals and plants came into existence, and were maintained in existence. The correct title for his book, therefore, would have been *The Origin of Features*, not *The Origin of Species*. But in his head, just as in that of most biologists, the two definitions of the species were perpetually crossing each other. If, equipped with the foregoing explanation, you study, for example, what he says about the problem whether mankind consists of one or many species (*Descent of Man*, 1909, p. 268 *et seq.*), you will easily note the constant vacillation between a merely descriptive and a genetic concept of the species.

Occasionally, we meet with the statement that the species are younger than the genera, the genera younger than the orders, etc. This sentence, too, makes sense only if we think of the species as a bundle of characters, not as individuals. For certainly it is the same individual which belongs to a species, a genus, or an order. And the same individual cannot be older and younger at the same time. But the characters which are used to distinguish the species from each other are considered younger than those which are common to the whole genus.

Of course, the idea underlying all this confusion is that descriptive resemblance is a means of recognizing common descent. How far this idea is in itself correct is a matter of argument and experience. But one thing is positively certain:

A clear formulation of the species problem can never be attained unless the two factors Resemblance and Descent are carefully kept apart.

How can this be done?

Odd as it may seem, we have to go back to Kant, Immanuel Kant, the German philosopher, to get an inspiring reply to this question. Kant, who took a very keen interest in natural science and was constantly concerned with biological problems, raised an important objection, which unfortunately is still valid to-day, against the science of his time. He criticized the habit of using the terms *Description* and *History of Nature* in the same sense. It is obvious, he said, that the knowledge of natural things, as they now are, should be completed by a knowledge of what they were before and how they came into the present condition. The *History of Nature* would teach us the gradual alterations in the shape of the earth and in the shape of its creatures. It would show the changes resulting from migrations and the possible deviations from the image of the original stock resulting from them. Such a history, says Kant, would probably reduce a great number of apparently different species to races of the same species. Linné, Buffon, and other scientists have often enough attempted that kind of explanation, however much or little they may have achieved with it. Such ideas, however, should not be inserted occasionally between the description of organisms, but rather form a separate science.

"Two lines of investigation as disparate as these should be separated from each other. Perhaps the History of Nature will never be more than a rough outline, perhaps for most questions no answer will be found —still, this advantage would be gained that heterogeneous matters would no longer appear mixed up with each other."

We have nowadays a full-dress History of Nature in the real sense of the word, and no modern naturalist would raise the ob-

jection which one of Kant's contemporaries made, namely, that this would be a science only for gods who had been present at everything from the very beginning.

But—is it not burlesque?—we do not call it History, and what we really do call Natural History, that is for the greater part mere description. If you doubt this statement, ask yourself what a Natural History Museum contains. We find in it indeed some real history, the demonstration of successive layers of the earth and their contents, some phylogenetic details, graphs of migrations or of the former shape of the continents, but you will admit that huge spaces are entirely filled with an accumulation of samples from all the realms of nature and all the countries of the globe, brought together simply for the sake of comparison without any regard to their history.

* * * *

If we now return to our systems of classification, we find the situation is very much the same. Originally, the systems were, of course, based on purely superficial resemblances. Later it was considered the task of systematics "to incorporate into the descriptive system the results of phylogenetic investigations". If this is done, the impression is created that the entire system is based on such phylogenetic investigations. And yet the system is more or less complete, and our knowledge of inner relationships is deplorably incomplete. 160 years ago, Kant wrote: "We pride ourselves with pretended knowledge regarding one of these sciences (history) which really pertains to the other." How strikingly true this still is.

Is Kant not right when he says that scientific honesty demands the analysis and dissolution of such a heterogeneous compound? The remedy which he suggests consists in the construction of two entirely separate systems of classification: one corresponding to the descriptive viewpoint, which classifies according to external characters without bothering about the history of the creatures, and which he calls the School System—and a second one, termed by him the Physical or Natural System, which refers to the possible inner relationships.

If we use two systems instead of one, we must also have two sets of terms at our disposal, and there should never be any doubt as to whether a term belongs to one set or the other.

"The School System", says Kant, "divides the animals into classes according to their resemblance; the Physical System divides them into tribes according to their blood relationship.

"As long as we consider wolf, fox, and dog with respect to their shape only, without investigating their origin, we may say that they form a class. But as soon as we are concerned with their descent, we apply other categories. Suppose we ascribe a separate origin to each of these animals, we would call each of them a genus. If, however, we believe that they have descended from common ancestors, we should say that they are races of the same genus (or species, for that matter, because in the physical system genus and species is the same, namely, a group of common origin)."

I will not enter here into more details as regards the terminology conceived by Kant. But I shall try to draw consequences from his principle. So we are now working out the concept of two systems of classification, the descriptive school system and, quite apart from it, a scheme for whatever scraps of knowledge or guessing concerning the history of organisms may be available.

* * * *

A system exclusively concerned with blood relationships will most naturally make use of all expressions which we are accustomed to apply to human relations, such as family, kinship, breed, lineage, strain, and also genus.

Although the word genus, like species, implied originally a logical category, there is an essential difference between these two

words as regards their later development outside the realm of natural science. While all derivatives of the term species, such as specification, speciality, specimen, have a distinctly "anorganic" character, there is a pronounced connexion between genus and genes, genetics, generation, etc., and this term is fundamental for the phylogenetic system. In German, similarly, the word "Gattung" is associated with Gatte, Gattin, begatten, whereas "Art" has no such association with family affairs. In fact, the only distinction as yet made in modern biology in the direction here proposed is that between the genotype and the phenotype—the genotype of an organism being determined by the hereditary units called genes, while the phenotype is simply its outward appearance.

In the descriptive system, on the other hand, all words hinting at family relations should be strictly banned, and only terms of a purely logical meaning, such as class, order, division, section, subsection, etc., permitted.

* * * *

According to what I said before, the term species might, on principle, well find its place among these logical categories, but when we think of all the confusion and bewilderment which this unfortunate word has brought to biology, it would seem unreasonable to build up a new system and allow this mischief-maker to dwell in it.

There are a number of other words, not quite so bad as species, but still dangerous enough, because you cannot tell at first sight in which sense they are being used. An author may speak of a variation, having nothing in mind but a simple resemblance. The reader, however, is liable to suspect that a real transformation from one form into the other has actually been observed. Often we read about related or "closely allied" forms, and in many cases I have been unable to find out whether these terms were to convey the idea of resemblance or of congenerity.

Another danger spot is the word "to derive". Here is an instructive example: The French zoologist Etienne Geoffroy de St Hilaire stated that all organic forms derive from one another ("toutes dérivent les unes des autres"). Superficial readers interpreted this sentence as denoting real descent. But what the writer had in mind was nothing but a purely ideal, logical and reversible operation, a derivation of one form from any other form, based on a common type supposed to underlie them all.

Such misunderstandings show how exceedingly important it is to choose entirely different words for the phylogenetic and for the descriptive complex of thought.

It seems to me that the best, or indeed the only way of bringing order into the manifoldness of organisms without prejudicing any ideas concerning their inner relationships would be the construction of a *Decimal System*. We may conceive an idea of how such a system might work if we think of those various keys which are used for determining the names of a given plant or animal.

The first job is to *give* names to every animal or plant, and it has been pointed out that God thought this business so important that it was the very first thing He ordered Adam to do, even before getting him a wife. Then, when the names are given, the next important thing is to enable everybody to know them, so that when one person wants to speak of a certain plant, all others can know what he is talking about. This is really the main use of a descriptive system.

In strict opposition to the demand of those who desire to incorporate the results of phylogenetic investigation into the descriptive system, and who, consequently, want it to be flexible, and elastic, and "frequently revised so as to adjust itself to the newer viewpoints"—the decimal system would have to be absolutely rigid and fixed once and for all just as a system of mathematical co-ordinates is and must be, in order to act as a common and reliable and per-

manent centre of reference for all forthcoming problems and discussions. Let then the students of phylogenetics indulge as they please in their own private theories, let their conjectures fluctuate from year to year, from man to man, they would simply announce that according to their opinion the animals 7139275... and 7132908... are of common descent. Such a hypothesis would not disturb the descriptive system which keeps itself entirely free from all concepts about possible inner relationships and is nothing but a systematic catalogue of single characters arranged according to definite rules.

I mentioned the analytical keys as the nearest approach to such a system, and it will be instructive to note the similarities and the differences. The fact that modern text-books contain sometimes such a key at the side of the so-called natural classification proves that a partition of this kind is desirable. Hutchinson follows this method in his *Families of Flowering Plants*, Turner has treated a small section of crustaceans, the crayfish, in the same manner, and similar practical instruments have been devised for various groups in the vegetable and animal kingdoms.

The inventor of the key method is the well-known French naturalist, Jean de Lamarck, the pioneer of Lamarckism, who was a botanist in the eighteenth and a zoologist in the nineteenth centuries. Cuvier supplied the French Academy of Sciences with the following nice description of the method: "Starting from the most general conformations, dividing and subdividing by two, giving each time the choice among only two opposite characters, this guide takes the reader by the hand and leads him so as to make him inevitably, and even in an entertaining manner, arrive at the determination of the plant whose name he is looking for."

The general conformations from which analytical keys start are not always the same. Linné began by counting stamens and called his main classes Monandria, Diandria, etc., which means in his own translation, "One man in the marriage, two men in the marriage...". Then he got his second category, the orders, by counting the female partners, the pistils. Lamarck began his key with the enquiry whether the flowers are united or separate, and, if united, all of the same kind or of two kinds. Hutchinson starts with an investigation of the carpels. Is there only one or more? Are they separate or united?

* * * *

The possibilities for different starts are numerous, and it would be a very serious problem which to choose, if such a choice was absolutely necessary. But perhaps it is not. Perhaps it is quite possible to do without it, to avoid a hierarchic structure which places one single feature, as it were, at the top of the scheme and treats the others as if they were of minor importance. The decimal system will resemble a democratic rather than a monarchic regime, with representatives of all parties concerned enjoying equal rights. Again, whereas the usual keys are careful to give the choice each time between two opposite characters only, the lists for the decimal system will enumerate simultaneously all occurrences which are possible and exclude each other.

Another difference is that the keys are always arranged to suit some particular groups of real plants which the author has in mind while constructing his scheme, and, as a consequence of this condition, the descriptions offered for our choice are sometimes rather involved. I envy people who, for example, are able to take in the following instruction without getting a headache: "Gynoecium composed of one carpel or of two or more united carpels with free or united styles, or, if carpels free below, then the styles or stigmas united."

The decimal system will not operate with Ors or Ifs. It will present every single character in an abstract and general manner so as to fit all possible cases, even those of yet unknown plants (or animals). To arrange all organisms in accordance with

the system will be a subject for a thousand doctorate dissertations. I have no doubt that the first pronouncement of experts will be: "It is impossible"; but I think, with Goethe, that one must always aim at the impossible in order to accomplish what is possible.

The first task will be to put up an atlas which contains a full inventory of all botanical characters, including cytology (chromosome numbers, etc.), anatomy (stomata, vascular bundles, etc.), chemical and physiological distinctions and ecological peculiarities.

An embryonic sketch of what such an atlas might look like is here presented in the leaf tableau (Fig. 1). I am much indebted to the intelligent co-operation of a young artist, Ronald Searle, who drafted the charts. Incidentally, his description of "botanical shorthand" for my endeavours would also seem worth accepting. This rudiment chart, of course, does not aim at completeness; its purpose is simply to illustrate the method.

Each division furnishes one decimal, the first decimal indicating the position, the second the general form of the leaves, the third and fourth the special configuration of tip and base, the fifth the venation, the sixth composition, the seventh the appearance of the edge, the eighth hairiness or other of the surface. A ninth decimal might account for the colour, and so forth.

The description

	I,	II,	III,	IV,	V,	VI,	VII,	VIII,...
Leaves	4	(13)	1	3	2	0	6	9

would mean that the leaves are arranged in whorls of four (no. 4 of first division), that they have the form of a sword (no. 13 of second division), that their tip is acute, their base sagittate, their veins parallel, that they are simple (composition 0), their edge is toothed, and their surface woolly—whether such a leaf exists somewhere on our globe or not.

As far as possible, all characters should be shown graphically. Colours may be displayed in a special chart so that they too can be indicated by figures.

When books supply illustrations for the purpose of explaining a term, it is often confusing that they convey the portrait of one individual plant which does not even show the character in question very strik-

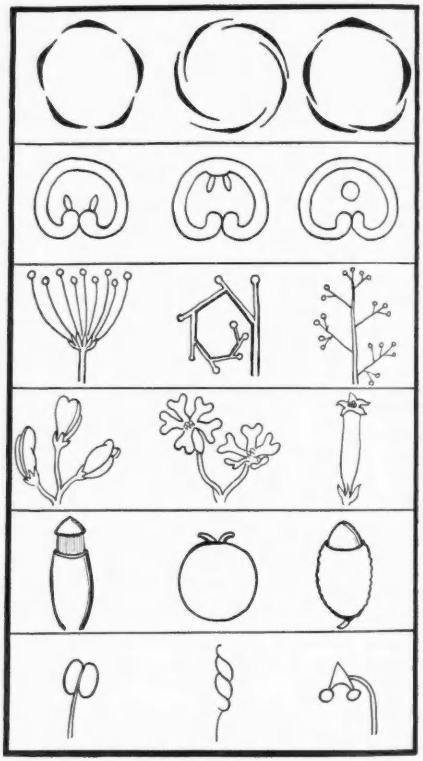


Fig. 1

ingly. I have found "lyrate" leaves in which I failed to discover a lyra. But even if the chosen individual happens to show the desired character distinctly enough, it is often accompanied by other features of which the student cannot know whether they are essential or accidental. I once saw an "orbiculate" leaf with a crenate edge, which suggested the question whether the word orbiculate referred to the roundish

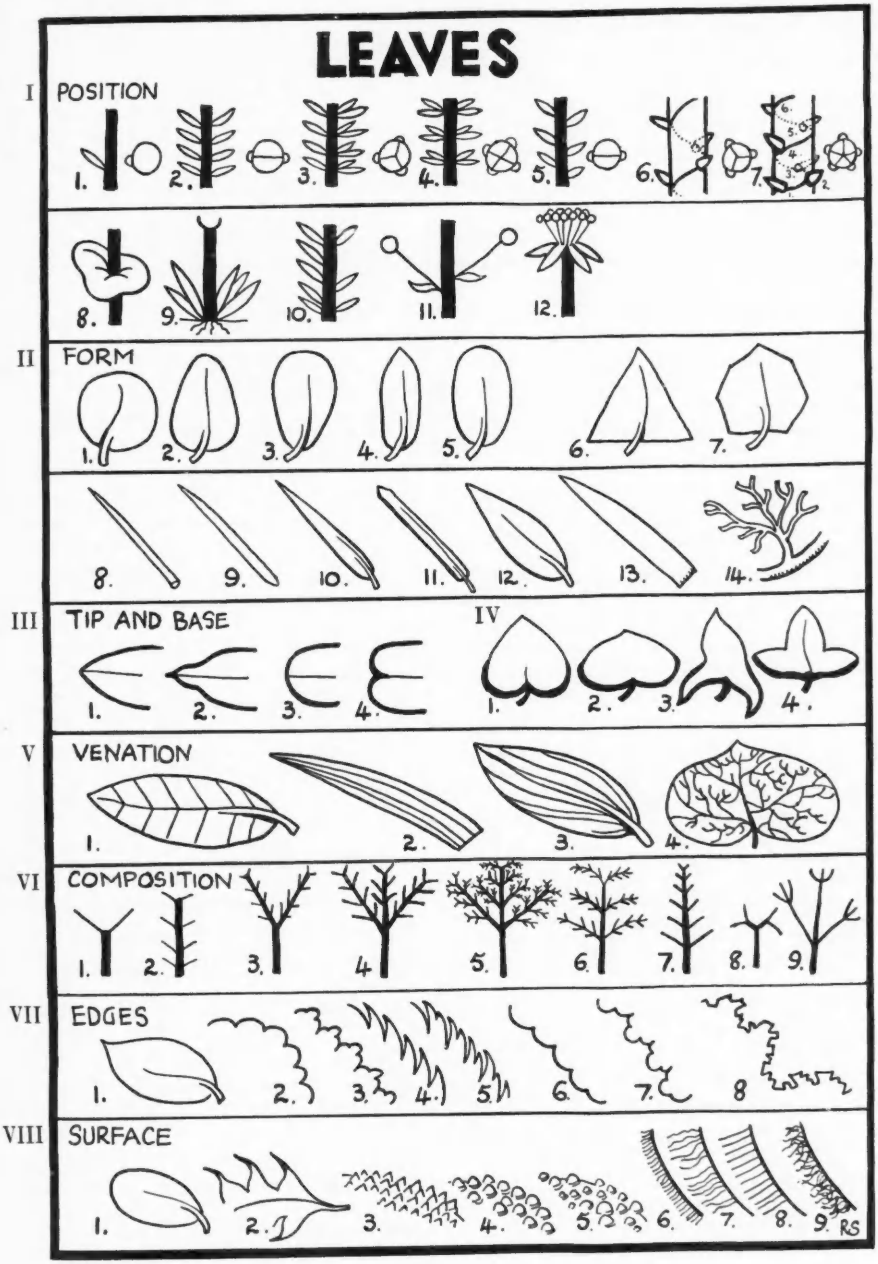

LEAVES
I POSITION
II FORM
III TIP AND BASE
IV
V VENATION
VI COMPOSITION
VII EDGES
VIII SURFACE
RS

Fig. 2

form of the blade or of the teeth. Therefore it is important that the chart should not portray real plants, but give only clear symbols of the one feature that is to be demonstrated, as, for example, in Fig. 2, where schematized graphs exemplify some forms of aestivation, placentation, inflorescence, flower shape, fruits, and anthers.

Some characters of general importance which appear in different organs of the plant might be given special symbols. Thus, for example, in descriptions of petals, sepals, carpels, and styles, we hit again and again on the distinctions "free", "slightly united", "united". These possibilities might be expressed in the following manner: | | free; ⊔ united at base, ⊓ united at top, ⊟ fully united. The symbol [5⊔] would then mean five petals (or sepals) united at their base. The cornered brackets are meant to indicate that the figure enclosed by them is not only a decimal, but a real number. To state such numbers or results of measurements directly, is obviously a simplification, and I think that cornered brackets or some other symbol of the kind would be sufficient to prevent confusion arising therefrom.

Certainly it would be possible to arrange statistical data, such as, for example, Dr J. Gregor has published in his interesting papers on "Experimental taxonomy" (*New Phytologist*, 1936, 1938) according to the same principle. It is significant that experimental taxonomy employs new terms (geotype, ecotype, topotype) to characterize the populations studied, in order to distinguish these populations from any phylogenetic units as well as from the units of orthodox taxonomy. It is also significant that Dr Gregor, in agreement with H. M. Hall (*Congress of Plant Science*, 1926), recommends that small units should provisionally be presented "in a numbered or lettered list", which would make all the material available to other research workers without compelling the systematist to commit himself when evidence is lacking. That is exactly the object which, on a wider scale, the strictly descriptive method here proposed tries to make possible.

Beyond this immediate purpose, the need of which has been felt by many scientists, it is exceedingly probable that when all plants have been arranged in accordance with the decimal system, new rules and regularities will reveal themselves. When, in the present state of confused and unsystematic systematics, a botanist wants to know whether two characters are frequently occurring together and may be correlated, he is forced to undertake special field studies for the purpose. But when the decimal description of all plants is completed, it will be easy for him, sitting quietly at his desk, to discover how often the character Leaf . . . . 7 occurs combined with the character Root . . . . 6.

And it might well occur that unknown regularities will reveal themselves with every rearrangement.

"BOTH biological and physical research are frankly universal. A piece of research to-day may incorporate contributions from a worker in Japan, a worker in New York, a negro in Washington, or a Danish or a Portuguese laboratory. All honest workers are equal citizens in this noblest of republics. And when any of them meet some great leader like Rutherford or Einstein, there is no need for them to make some currish salute in recognition of the leader. And there is no need for him to plaster himself over with feathers and medals and decorations to assert himself."

H. G. WELLS

THE ORIGIN OF COMETS

The Director of the Comet Section of the British Astronomical Association here discusses the various theories so far put forward about the origin of comets.

THE question of the origin of comets has an important bearing on another problem for which no adequate explanation has hitherto been offered—the problem of the origin of the solar system. Although it is not proposed that this matter should be dealt with in the present article, it may be pointed out that most of the theories relating to the origin of the solar system largely ignore the difficulties of fitting in the cometary system with the scheme proposed. If cosmogonists had made a more careful study of comets, it is certain that they would not have made so many mistakes in propounding theories of the origin of the solar system, which subsequently proved untenable.

A problem confronts us at the beginning of our enquiry and that is the difficulty of generalizing about the origin of bodies which have such a very wide range in the nature of their orbits. They move in orbits with every inclination and, on the whole, show no preference for either direct or retrograde motion. In some cases the curves that they describe in their motion around the Sun are almost as circular as are those that are found in certain of the minor planets, while in other cases they are practically indistinguishable from parabolas. Some of them make very close approaches to the Sun, almost skimming its surface, while others do not approach closer than two or three astronomical units, and it is fairly certain that many do not make nearly so close an approach as this, for which reason they escape detection. There is one feature common to all comets and this is very important for various reasons; out of nearly 600 comets, the orbits of which have been computed, not one has been found to move in a hyperbolic orbit, unless, as sometimes happens, the perturbations of the planets have been responsible for throwing them into such an orbit. For this reason comets must be considered true members of the solar system.

It is well known that certain comets have short periods—the best example is Comet Encke with a period of about 3½ years—and that others have very long periods, in some cases running into tens of thousands of years. Dealing with the former group, there are certain families of which the aphelia, that is, their greatest distances from the Sun, are grouped near the orbits of the great planets. Jupiter has over fifty in his family and the motions of all of them are direct. Saturn has only two in his family and their motions are also direct. Uranus has three and of these one has retrograde motion; this is the well-known Comet Tempel which is responsible for the Leonid shower of meteors in November. In Neptune's family of seven comets there are two with retrograde motion, Comet 1827 and Halley's Comet. On first appearance there seems to be something attractive in the theory that these comets associated with the major planets were once long-period comets and in their passage near the planets they were partly captured by the latter, their velocities being reduced and their periods of revolution around the Sun shortened. Unfortunately the theory breaks down on the question of probabilities, as pointed out by the late Dr A. C. D. Crommelin many years ago. He showed that a comet could not be annexed

in the manner postulated by Jupiter unless it passed closer to the planet than its satellite Callisto. Knowing the angle subtended at the Sun by the line Jupiter-Callisto, it is easy to find the probability of a comet coming within a sphere of this radius, and as three comets, on the average, approach the Sun each year, it is easily deduced that 200,000 years would be required for Jupiter to annex a new member. As the life of a short-period comet is very limited, a large amount of dissipation of material taking place at each return to perihelion, that is, the nearest approach to the Sun, the capture of a comet once in 200,000 years would be utterly insufficient to balance the wastage which is going on. Another objection is that the differential attraction of a planet would break up the head of a comet, which consists of a loose agglomeration, and the particles would pursue different orbits. The strongest objection is that all the members of the Jupiter family have direct motion, from which it is obvious that the planet has some other role than that of a captor.

More than sixty years ago Richard Proctor advanced the view that the short-period comets were ejected by the major planets. Our recent knowledge of the physical conditions of these planets seems to militate against this view, as the temperature of Jupiter is about 200° F. below zero and Saturn is colder still, and it does not appear very probable that eruptive action would occur in these circumstances. It has been shown in recent years, however, that the temperature of Jupiter rises as the centre is approached, and the view of Dr Jeffreys that the planet had a thick layer of ice is no longer held. Under the cold gaseous exterior there may be intense heat, and the westward drift of prominent markings indicates eruptions in the interior where the rotational speed is less. The same remark applies to the westward motion of the white spots on Saturn, and there is no *a priori* objection to the ejection of matter on the planets through surface disturbances. Although the theory has commended itself to some it must be admitted that there are various objections to it. Crommelin's view, that direct motion in the case of Jupiter's family could be explained because matter ejected from the front of the planet in his orbital motion around the Sun would be more likely to pass beyond the control of Jupiter than matter that was ejected from the opposite hemisphere, is open to difficulties. In the case of the other three major planets the same argument would not apply owing to their smaller gravitational effects, and so we should expect some of their families to have retrograde motion. While three retrograde comets are actually found in the families of Uranus and Neptune, thus adding weight to the theory, it is remarkable that Saturn should have only two comets, both with direct motion. If the short-period comets are formed by the ejection of matter from the planets, why should Saturn have only two comets while Neptune has seven? It cannot be argued that surface activity is very much greater in the latter case to produce so many comets, and the subject still presents many difficulties.

It would exceed the limits allotted to this article to consider other theories of the origin of the short-period comets, and we must now deal briefly with the other class—the long-period comets. Professor C. Olivier attempted an explanation on the assumption of the catastrophic origin of the solar system. He believed that eruptions from our primitive Sun took place in polar as well as in equatorial regions, and in the former case the hotter material from the interior was brought nearer the surface. Eruptions of this hotter material would take place all around the belt from poles to equator, and this would explain retrograde motion and high inclinations. The theory assumes that comets were formed when the planets were torn from the Sun about 3000 million years ago, or more, but it is impossible to believe that short-period comets have survived for this period. Olivier thinks that these dis-

Comet iii of 1908. *The Star images are elongated because the telescope was made to follow the motion of the comet, which was moving past the stars*

appeared long ago and that the present short-period comets were originally long-period comets which have been forced into smaller orbits by the perturbations of the planets or perhaps by passing through resisting media beyond the limits of the solar system. It should be pointed out, however, that planetary perturbations would not only change long-period comets into short-period comets but they would also drive many of the long-period comets out of the solar system. In addition, as the tidal theory of the origin of the planetary system has been discarded in comparatively recent times, it is useless to consider a theory of the origin of comets that is based upon this.

About ten years ago Bobrovnikoff developed a theory that the Sun captured the comets not more than a million years ago when it was passing through diffuse clouds of obscuring matter. It is true that our Sun is moving round the centre of the galaxy, completing a revolution in 224 million years, and in comparatively recent times, less than 10 million years ago, must have been in the neighbourhood of the Great Nebula in Orion. Did it emerge from a region containing a large amount of meteoric matter with a supply of cometary material? If so it is difficult to explain why this region consisted of fairly large agglomerations of matter of various sizes as well as of cosmic dust. Why bodies of such different sizes should exist and why or how they formed comets is a problem. Again, even the comparatively short time of a million years is much too great because comets disintegrate so quickly and none would exist for such a period.

This article set out to discuss the origin of comets, but it is impossible to say how or where they originated. It may appear humiliating to make this confession, but our ignorance on an apparently simple subject of this nature is only too typical of our ignorance in general. When more light is thrown on the origin of the solar system it is possible that something more definite may be known about the origin of comets.

M. DAVIDSON.

MICHELANGELO IMPROVED UPON

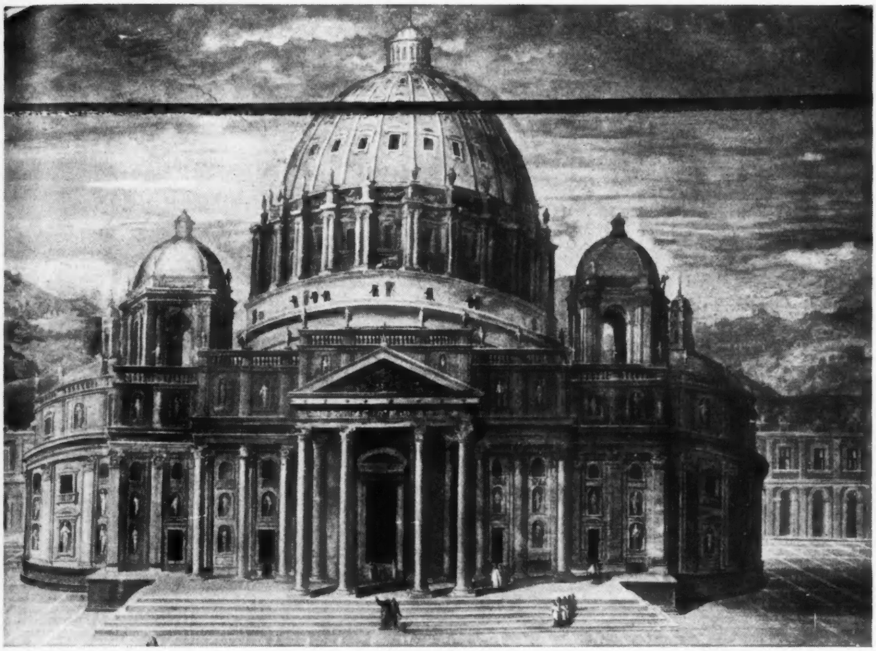
An enquiry into the tradition that the dome of St Peter's was designed by him, leads to a new theory.

OFTEN the legend of tradition has greater weight than a critical judgement. Yet there are cases which prove that advantages may come from the destruction of the legend; and an example of this is the history of the building of the cupola of St Peter's in Rome.

Most people believe that this wonderful cupola is the creation of Michelangelo, though it could be shown with certainty that this opinion is not according to the facts. The most striking proof of this is the fact that the preserved model of the cupola was finished as late as 1561, that is, when Michelangelo was 87 years old. It is not to be supposed that in the last three years of his life he altered the whole conception of his design.

It is not important here to discuss details of the history of art: our task is to find out Michelangelo's original intentions, and to trace the influence which caused the divergence from his plans which can be seen in the cupola of to-day.

When looking from the Janiculum to the cathedral one is always enchanted by the cupola rising into the sky. What would the cupola have been like if it had been built



The cathedral of St Peter's as it was planned by Michelangelo. From an anonymous fresco of the sixteenth century in the Vatican

Opposite: *The cathedral of St Peter's as it is today*

according to Michelangelo's plans? The external shell would not have been so tall; the radius of the drum would have been just larger than the height of the cupola. The groins of the dome, therefore, would have sprung at a flatter angle from the pilasters. The contour would have been an almost semicircular arch. The stress on the groins would have been on their mid-point as the heavy weight of the lantern pressed down on them. Here also, as in the sculpture of Michelangelo, can be seen the constant struggle between physical strength and an overpowering burden.

From the square one would have entered the central building through a vestibule resembling the Pantheon in its many columns. Attracted by the brightness of the centre one would have passed quickly through the short, dark, barrel-vaulted nave. The dark adjoining rooms would have been dominated by the tremendous height and width of the central room, like globes revolving round the sun.

The vault was planned almost as a hemisphere; it would have stood over those walking below like a heavy bell. It was intended to have only a very plain and sober decoration of alternating rectangular and circular panels between the groins. Nothing in the plans reminds us of the Baroque ecstasy of the actual construction. The religious fervour of the old master was expressed in this design.

The old master's peculiar art would have been shown distinctly by the lighting of the interior of the cupola. The vault would have become darker and darker towards the apex, and at the top a deeply shadowed ring would have joined the groins. From there one would have looked into the twilight of the circular opening of the

The interior of the cupola as it was planned. A photograph of the wooden model built according to the designs of Michelangelo

Renaissance, the spirit of "humanitas". His plans do not yet show the Baroque ecstasy of the construction done under the direction of G. della Porta.

Only by separating Michelangelo the artist from Michelangelo the engineer, the aesthetic from the technical problem, can one realize the great importance of Michelangelo's project, in spite of later alterations. Porta executed the cupola about 8 metres higher than in Michelangelo's plans. From the aesthetic point of view this alteration profoundly changed the outline of the building, the plan and execution express two epochs, the Renaissance and the Baroque. But from the technical point of view the cupola, as built, still follows Michelangelo's conception.

Michelangelo had deeply studied the construction problems of the cupola at Florence. Now, considered technically, the Florentine cupola appears more primitive and awkward than the Roman one. The material in its construction does not quite correspond to the stresses, and it could have been built with much less material. The technical excellence of the cupola of St Peter's is due to the fact that the intended design was realized with the least possible material. The most striking argument for this is the following fact. As already said, Porta increased the height of the cupola by about 8 metres; thus the whole mass of material had to be increased. But the planned construction would not take this greater weight. Therefore iron chains were fixed at

lantern. This type of apex would have resembled that of the Pantheon; one would not have looked into a bright flood of light as now, but into a soft and dusky clearness.

It seems impossible that the executed cupola, admired as Michelangelo's boldest work, should differ so much from the aesthetic intentions of its designer; yet it does so. Michelangelo's conception expressed the harmonious spirit of the

The interior of the cupola as it is today

the drum, and so increased its holding capacity.

This minimum of material produces the cupola's great elegance. One of the claims of modern architecture was already realized by this type of construction: the intended design was built by the least awkward and most expedient technical means.

The cupola of St Peter's is the climax in the evolution of the construction of Occidental cupolas. This evolution began with the tombs of the Mycenean and Etruscan civilizations excavated from mounds of earth or stone. In the Roman period the cupola, erected upon a round construction and with only one bowl, rose proudly above the ground. At the beginning of the Renaissance the cupola was elevated once more: it was no more an independent construction, but the sublime coronation of a more complicated building. Although Michelangelo based his work on Brunelleschi's two-shelled cupola, it was he who created the final type which is yet unsurpassed.

(*a*) (*b*)

Schematic sections of (*a*) *the actual cupola and* (*b*) *the original design of St Peter's*

PAUL M. LAPORTE.

THE SUBMARINE OF TO-DAY

EXPERIMENTS with submarines carried out in France and America at the end of the nineteenth century were watched very closely by the British Government, and, when the success of the *Holland* submarine made it clear that the development of submersible boats had passed from the purely experimental to the practical stage, steps were taken to build up a submarine fleet. This was in 1900. Since then such craft have progressed by leaps and bounds, both in size and as examples of technical skill and ingenuity.

The cigar-shaped hull of a modern submarine is surmounted by a deck that extends for roughly half its length, and carries the gun superstructure and conning tower. This tower is topped by the navigating bridge on which are the compass, steering wheel and other navigation instruments. This equipment is used when the submarine is on the surface, but is duplicated in the interior of the vessel for submerged navigation.

The conning tower is capped by a small dome-shaped hatch hinged like a lid. After the navigating officer has descended a steel ladder inside the tower, this hatch is pulled down before diving to form an absolutely watertight joint. The conning tower is built upon the hull, and in its floor or deck is a second hatch which, when closed, renders the interior of the submarine completely watertight, thereby ensuring that if the tower should be damaged by gun fire, or otherwise, the hull is kept watertight.

Inside the conning tower is a small compartment in which is the eyepiece of the periscope, together with the compass, recording instruments and telegraphs. Several ports or windows in the side of the tower enable the navigating officer to scan the surrounding sea until the vessel, in its descent, shuts off the view. He then utilizes the periscope, unless the submarine descends to a depth greater than the length of the periscope, in which case the hood of the latter is closed before it becomes submerged.

The tube of a modern periscope is approximately 30 ft. in length and contains about sixteen lenses and prisms. It is erected vertically and extends for many feet above the conning tower, while the base is inside the navigating compartment of the tower, and protrudes into the hull. It is mounted inside a protecting sheath or outer cover in which it can be rotated easily and quickly, and into which it can be drawn if required.

The torpedo tubes of a submarine—its most important weapons—are situated in the bow, amidships, and at the stern of the vessel. The interior detail equipment of a modern submarine is naturally a closely guarded secret. There is only one tween-deck and this carries the torpedo chambers, navigation compartment, crew accommodation and engine and motor rooms, while below this deck are the storage batteries and the fuel and ballast tanks—the latter extend up the sides of the hull as well—and the compressed air bottles.

The torpedo tubes are always loaded before a submarine leaves port, so as to be ready for immediate use. Additional torpedoes are also taken on board and stored in low wooden cradles slung near the tubes. The torpedoes are fired by compressed air stored in steel bottles at 2500 lb. pressure—which is also used to "blow the tanks".

Behind the bow torpedo chamber are the crew's quarters, and officers' space, and immediately below the conning tower is the navigation compartment, which contains a remarkable array of instruments. Here is a duplicate set of the navigation instruments housed in the conning-tower

compartment, gauges to indicate the vessel's trim, together with steering and control wheels for operating the ordinary rudder and the horizontal rudders or hydroplanes that project from the hull near the bow and stern. Between this compartment and the engine room (the propelling machinery and electric lighting plant are situated in the aft part of the submarine) is the officers' mess, and aft of the engine room is more crew's space.

When the Diesel engines are in use on the surface they are connected up to the dynamo, and by this means the accumulators below deck are recharged during their idle periods. A modern submarine is either a twin-screw or triple-screw vessel. The engines are placed on each side of a narrow gangway, and the motors are situated in line with the engines and propeller shafts. Clutches enable either the oil engines or the electric motors to impart motion to the propeller shafts either together or individually.

The engine room also contains the pumps necessary for emptying the ballast tanks (when they are not "blown"), pumping fuel oil, maintaining the supply of compressed air in the bottles, and regulating the ventilation in the hull in conjunction with the electric fans. Supplementary fuel tanks are sometimes placed in the double hull at the stern, slightly higher than the main tanks, to which the oil is allowed to flow by gravitation.

The conditions of stability of a submarine are quite different from those of an ordinary ship. In the case of a ship the centre of gravity is always above the centre of buoyancy; but in a submarine things are quite the reverse: to maintain stability both when on the surface and submerged the centre of gravity of a submarine is always *below* the centre of buoyancy of the displaced water. When the tanks are "blown" both the C. of B. and C. of G. move down slightly, but they stay in more or less the same relative positions.

When the tanks are full the vessel either sinks of her own accord, or is driven under by the combined action of the screws and the horizontal rudders or hydroplanes. A speed of at least 4 knots (4·6 m.p.h.) is necessary before these rudders can come into play. The limit to which she can dive is fixed by the capacity of the shell or hull to withstand the water pressure, which is about 45 lb. per sq. in. for every 100 ft. of depth. The maximum depth to which a submarine is known to have descended without being crushed is slightly over 400 ft.

To bring the submarine to the surface after a submerged run, the diving rudders are set at the correct angle for ascending, and the vessel is then forced upwards by the thrust of her screws. When she has reached the surface, the sea water is expelled from the ballast tanks either by pumping, or more frequently, by compressed air at 2500 lb. per sq. in., thus restoring her surface buoyancy.

A typical class of modern British submarine is 345 ft. long and 28 ft. in breadth, and her two 10-cylinder, 10,000 h.p. Diesel engines operate at 405 r.p.m. at full power, and give a maximum speed on the surface equivalent to about 24 m.p.h. She displaces on the surface 2165 tons, and 2680 tons when submerged. Her hull is strong enough to enable her to dive to 400 ft. Her oil-fuel tanks are large enough to enable her to travel half round the world without refuelling. The safety equipment includes two Davis escape hatches and a special telephone buoy that can be released from inside the vessel in an emergency. The armament consists of a 4·7 in. gun carried in a revolving armoured hood, and six large torpedo tubes. Some submarines have been built to carry aeroplanes as well as guns. The world's largest submarine is the French *Surcouf* of 2880 tons surface displacement.

It is interesting to record that the submarine "merchantman" made its appearance during the Great War in the *Deutchland*, which twice safely proceeded to the United States. She cost some £100,000 and was manned by a crew of twenty-nine,

but she carried only 750 tons of cargo. A sister vessel was also built, the *Bremen*. But it is now generally realized that the submarine is essentially only a weapon of war. When will the World become sufficiently civilized to abolish these dangerous and otherwise "useless" craft?

J. GORDON PEIRSON.

Ultra Perception

SOME COMMENTS BY W. W. CARINGTON

DR HETTINGER describes (*Discovery*, December 1939, p. 653) what is evidently an extremely interesting contribution to the growing list of attempts to apply quantitative methods in the difficult field of so-called "paranormal" psychology; moreover, he breaks new ground, for this is, I believe, the first time anyone has tried to apply such methods to the particular class of phenomena he has studied. Very baldly, for those who have not read the article, two professional sensitives gave their impressions of the characters, histories, circumstances, or the like, of the owners of objects submitted to them by Dr Hettinger, the owners being unknown to the sensitives and not present at the time. Statistical treatment of a large number of trials yielded a highly significant result. In a later series of experiments, not statistically controlled, a subject reads a paper or looks at illustrations therein, noting the moment at which he considers each picture or paragraph; the experimenter contemporaneously records the impressions received by the (distant) sensitive. Here again a degree of correspondence not attributable to chance was judged to occur. It is suggested that light might be thrown on psychological processes from a fresh angle by studying the differences between the original picture, etc., and the impression described by the sensitive.

All such attempts, provided they are properly carried out, should elicit nothing but approbation from scientific men, whether sceptical or otherwise, since it is only by the substitution of exact and rigid tests for wish-thinking and guesswork that the subject can be lifted out of its present condition of "pious opinion and personal abuse" onto whatever solid foundations it may deserve. And it is correspondingly necessary that all pioneer work of this kind should be subjected to the severest reasonable criticism that can be brought to bear.

Speaking quite personally, I find very little difficulty in accepting Dr Hettinger's main findings as veridical; but I do not think I should feel quite so ready to do so if it were not for the fact that, in recent months, I have myself obtained highly significant positive results from ordinary people recording their "impressions" of distant drawings, which they quite certainly could not *see*, and under conditions which I believe to have been completely rigid.* This gives me certain advantages as a critic, as well as an appreciator, of Dr Hettinger's work; but it is a fact which cuts both ways, for I am acutely aware that anything I may say here may very properly be "used against me later" when my own efforts come under fire. It is

* The Editor kindly allows me to take this opportunity of saying that it is hoped shortly to organize further experiments on these lines, in which readers of *Discovery* will be invited to participate.

accordingly with some sense of trepidation that I venture to call attention to one or two points which seem to me not wholly satisfactory in Dr Hettinger's account of his work.

First, then, he insists, so early in his second paragraph, that there is "no comparison whatsoever" between his researches and the experiments of Dr Rhine on the guessing of symbols on cards, and he draws attention, quite correctly, to certain notable differences. But despite these, the essential "set-up" is identical in his, Dr Rhine's and my own cases; that is to say, in each case *someone* (Dr Rhine's or my normal percipients, Dr Hettinger's sensitives) is required to give information about *something* (the card symbols, the drawings, or the owners of the objects submitted) of a kind which cannot be attributed to sense perception or rational inference. Unless this last condition holds, the experiments are so much waste of time. If, for example, the cards can be read from the back, as some cards can, and the percipient is in a position to do so, or if it were possible for my subjects to catch even the most fleeting glimpse of the drawings, the supposed facts on which the subsequent statistical treatment and resultant inferences are based cease to be facts at all, and the whole theory collapses. In my own case, if I had so much as made a drawing in the same room as a potential percipient, the more stringent critics would have had some ground for talking of the possibilities of "involuntary whispering", reflections in polished surfaces, or the guidance given by the sound of pencil scratchings.

In the same way, we want to be absolutely sure, so far as such an uncompromising phrase is permissible in human affairs at all, that Dr Hettinger's sensitives had no chance whatever of gaining any relevant information from normal observation of the articles submitted to them. It is true that these were enclosed "in sealed envelopes"; but, even so, it would not require a Sherlock Holmes to make a series of remarks more appropriate to each of the owners than to the other if two objects so enclosed were a scented powder puff and a well-used pipe. It seems to me that the critic might not unfairly point out that professional sensitives would not long remain in business unless they possessed exceptional powers of *some* kind, and that these might take the form of an ability to draw, like the immortal detective, very striking conclusions from very slender clues.

I should like to make it clear that I myself do not think it at all likely that Dr Hettinger's results are due to this cause; but I do not see how one could stigmatize as unreasonable anyone who suggests that the possibility has not been completely excluded. I should feel a good deal happier if, for example, all objects had been enclosed in suitably sealed rigid boxes of standard size, wadded with cotton wool and perhaps, by way of painting the lily, brought up to a standard weight with some neutral substance such as sand.

Second, there is the question of the extent to which the use of the same subject (owner of an object) on numerous occasions might falsify, or at least distort, the results. I believe I am right in saying that some subjects were used many times over, though Dr Hettinger does not mention the point in his article. If this is so, there seems to be the possibility that the sensitive might score a lucky hit on some early occasion and then, recognizing the object if it were resubmitted (and we are not told that this was not done), might repeat the same remarks, or at least make allusions to the same topic; these would presumably be again "accepted" by the subject, and thus a plurality of successes would be recorded where only one was deserved. This is frankly speculative, and I am by no means sure that it might not work both ways and so cancel out in the long run; but I think there can be very little doubt that it would be preferable never to use the same subject twice, and certainly never the same object, making up for this restriction by a more sensitive method of scoring. Here again,

though I here feel that I am on the edge of unreasonableness, I should be appreciably easier in my mind if I were assured that this kind of possibility had been adequately considered and effectively eliminated.

Finally, there is the question of whether, on the assumption that Dr Hettinger's main results are to be accepted, his proposed extension of the method as an instrument of psychological enquiry is yet justified. Granting for the moment that a non-chance, not normally determined, relationship has been demonstrated in the mass between a sensitive's statements and the circumstances of the subjects, are we justified in concluding, as Dr Hettinger seems to do, that there is necessarily a one to one correspondence between the items in an illustrated paper studied by a subject and the contemporaneous remarks made by the sensitive? I should have thought myself that an *ad hoc* research of considerable magnitude, based on purely objective methods, would have been necessary to establish this to a sufficiently high degree of probability to entitle us to rely upon it. And if it cannot be relied upon in at least the great majority of instances, is it not extremely hazardous to attempt any theorizing as to why, when the reader is looking at one thing, the sensitive describes something not quite the same?

I speak feelingly here because, on the one hand, I have myself been strongly tempted to speculate as to the process of distortion which drawings certainly seem sometimes to undergo, while, on the other, I have found a strong tendency, which I believe I have established by purely objective means and not merely as a matter of opinion, for successful reproductions to be displaced, e.g. to occur one or more places late. If this were to occur to any appreciable extent unsuspected, it would clearly invalidate any attempt to investigate apparent distortions which was based on the assumption of strict synchrony.

In this subject above all others, where the implications of the facts, if they be facts, are likely to be of such fundamental importance to our conceptions of the nature of the mind and its place in the scheme of things, but where at present not one scientist in a thousand would concede that there are any facts to be considered at all, it is utterly imperative that we should neglect no precaution, take nothing for granted, and make no advance from one conclusion to another without providing coercive demonstration that such advance is warranted. Later, when the general acceptance of a few basic phenomena has been won, as I am tolerably confident that it will be, and a few basic "laws" hammered out, we may be able to take things a trifle easier and have some idea of what safeguards we may reasonably relax: but that hour is not yet.

Meanwhile, it is greatly to be hoped that Dr Hettinger will continue his researches, which, notwithstanding anything I have said above, represent just the kind of work that badly needs doing in "the present stage of the art". In particular, his "illustrated paper" technique, if I may briefly so describe it, seems extraordinarily promising; but I hope he will not mind my saying that I should like to see the precautionary measures screwed up a turn or two tighter and a statistical control applied at *every* stage.

VOLUME II

Binding cases, title pages and indexes for Volume II are now ready. Applications should be addressed to The Manager, Cambridge University Press, 200 *Euston Road, N.W.* 1.

NOTES OF THE MONTH

RADIUM SOURCES IN DEVON

SEVERAL years ago Mr G. E. L. Carter, a resident of Budleigh Salterton on the south coast of Devon, explored the somewhat inaccessible cliffs of red clay which extend from the beach of Budleigh Salterton to the west in the direction of Exmouth. Scattered over the steep faces of the bright red cliffs he found circular light patches which closer inspection showed to consist of more or less round cores of grey stone, surrounded by haloes of bleached, almost white clay (Fig. 1). The central cores varied from the size of a pin-head to that of a football and the thickness of the haloes was to some extent proportional to the diameter of the cores.

Figure 1. Radioactive nodule (centre) with bleached halo embedded in red clay

Figure 2. Section of radioactive nodule. The dark parts contain vanadium (⅔ natural size)

The cores themselves proved to be comparatively soft, and could be sawn through with a hack-saw. The interior showed a most intriguing pattern consisting of a lump of black material at the centre, which is surrounded by one or more concentric black and white shells (Fig. 2). At first Carter believed that these peculiar formations might be fossils of molluscs, but later he began to suspect that radioactivity might be connected with their origin. In order to test his hypothesis, he prepared a flat section of one of his specimens and left it in contact with a photographic plate in complete darkness for several weeks. The outcome of this experiment was surprising. The nodule, as Carter called his specimens, had taken a contact photograph of itself showing all its structural features reproduced in outline (Fig. 3). Obviously the nodule emitted a radiation which caused a blackening of the photographic emulsion.

It was when Carter tried to make his discoveries known that he encountered his first serious difficulties. As he is not a scientist, but a retired Indian Civil Servant, people were disinclined to believe that his findings were genuine. The few local inhabitants of Budleigh Salterton who had either seen the nodules or heard about them, had long convinced themselves that they were cannon-balls dating from the Napoleonic wars, although some of the men were rather vague about the question

how the cannon-balls got there. The people who were responsible for the geological survey of the district, on the other hand, were extremely sceptical as to whether the nodules really existed. Eventually, however, Carter succeeded in getting a chemical analysis of the nodules made, and later he found a young research student in Cambridge who was willing to investigate the apparent radioactivity of the nodules and the problem of their origin.

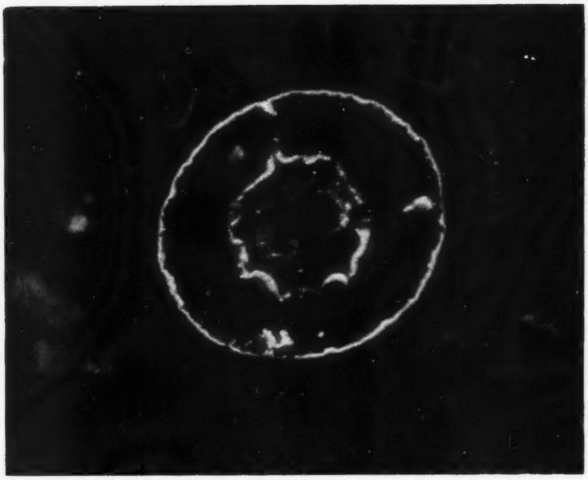


Figure 3. Contact photograph of section shown in figure 2. The white lines are due to radiation emitted by the nodule

Chemical analysis of the nodules revealed that the black portions contain a high percentage of the relatively rare element vanadium, which is a metal normally imported from Peru and extensively used in industry for the manufacture of high-quality steels, especially for springs. Other experiments soon showed that the radiation emitted by the nodules penetrates black paper and discharges a gold-leaf electroscope, criteria which proved beyond doubt the radioactive nature of the radiation. The source of the radiation was found to be an extremely thin layer of a uranium mineral which enveloped the dark portions of the nodules on both sides. Uranium by its slow radioactive decay produces radium which, in its turn, disintegrates further under the emission of radiation until it is finally converted into inactive lead. A nodule of medium size contains about one hundred thousandth of a gramme of radium or 1 % of the amount which is present in a corresponding quantity of pitchblende, the richest natural radium source known.

The nodules probably originated under desert conditions in the so-called Permian period, just after the time when our coal deposits were formed. They may owe their existence to the collection of vanadium salts by plants which are able to use vanadium as a substitute for phosphorus if the latter is absent in the soil, as happens to be the case in the red clay surrounding the nodules. Once vanadium salts are concentrated at certain points in the clay, uranium salts would naturally be deposited on the surface of the vanadium concentrations with which they form a chemical compound. The bleached haloes appear to be due to a radioactive gas—the first product of the decay of radium—which spreads from the interior of the nodules and bleaches the red clay.

The deposits of radium and vanadium near Budleigh Salterton are hardly extensive enough ever to become of industrial importance. They are, however, of great interest to the geologist, and they serve as a striking example of how discoveries are made by one person who has the ability to observe what scores of others pass without noticing.

PERUTZ.

(*Cavendish Laboratory, Cambridge*)

LIFE IN HOT SPRINGS

ALTHOUGH some animals can, when they are in an encysted condition, resist temperatures as extreme as those of liquid hydrogen and superheated steam, it is only over a far more limited range that they can display their characteristic vital activities. For the vast majority of animals this range lies somewhere between 0 and 38° C., but a few interesting species are able to tolerate somewhat higher temperatures, and are thereby enabled to colonize in some cases, sun-baked deserts, and in others thermal springs. A survey which has been made recently of such springs at Hammam Meskoutine in Algeria has yielded some interesting information with regard to their fauna. As the water is neither saline nor sulphurous, this region provides good material for the study of the effects of high temperature uncomplicated by other factors.

It appears that the inhabitants of the springs fall into three groups. The first, which includes the frogs, consists simply of animals living very close to their thermal death point. Frogs were occasionally found at 39°, and were abundant below 38°; experiment showed that immersion in water at 39° is fatal in 10 min. or so. The individuals found at this temperature must be presumed to have been paying a hasty visit to a region hotter than their normal home. In the second group are found species in which adaptive physiological races have been formed. For example the specimens of *Barbus* (a small fish) living in the coolest parts of the stream (maximum temperature about 20°) die at 33°, while those from warmer regions (maximum temperature 36°) can survive up to 38°. Finally, there are two species, a beetle and a small crustacean, which are confined to the hotter waters and are not found below 33 and 39° respectively. It seems probable that normal temperatures are not in themselves fatal, but that they permit the existence of competitors, so that these forms retreat for security to the hottest regions, which only they can tolerate. The crustacean was found at temperatures up to 51·5°. This is the highest temperature ever recorded for metazoan life, and is at least ten degrees above that at which most people take their hot bath.

D. A. W.

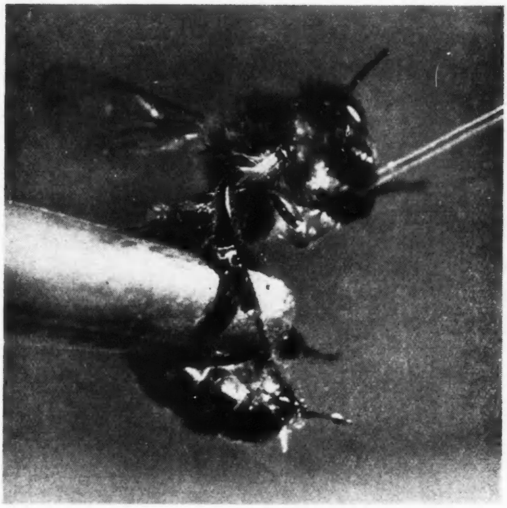
(*Mason; Hammam Meskoutine*)

THE ENERGY OF BEES

THE sugar content of the blood of vertebrates must not pass beyond a certain degree if cramp and weakness is to be avoided. The liver is the organ which manufactures and distributes carbon hydrates and increases the sugar content of the blood in cases of diminishing supply.

The question as to how invertebrates, like the bee, renew their used-up energy and the blood-sugar content, has been unanswered until now; for the bee has no liver with which to manufacture the carbohydrates. Yet the bee uses up tremendous energy: in 15 min. it can fly 2½ miles, that is, 10 miles an hour; in this period it makes 18,000 wing movements with an equivalent number of breast muscle contractions. In this flight it carries not only the weight of its body (about 75 mg.) but also a burden of 10–80 mg.; where does this energy come from?

In experiments and blood tests made to decide the average amount of sugar in the body of a normally nourished bee, Professor Bentler found that in the bee the blood-sugar content is higher than in any other investigated creature, and that the blood-sugar content varies considerably. The variation of the sugar content depends on



Extracting sugar from a bee

the physiological condition of the bee, on age and nourishment, and upon atmosphere and temperature.

With the succeeding experiments it became clearer that the high blood-sugar content of the bee is related to the exceptional activities of the creature and its muscular performance in flying, and further research was made to define the scale and degree of sugar. By careful preparation a bee was captured and tested on its way to seek honey: it showed 2% of sugar. After half an hour's flight in the "aquarium" it was again tested and gave 0·0%. But, as a bee does not normally fly much more than 2½ miles in a period of 15 min., halting to take nourishment, the exhaustion revealed in the test would scarcely appear normally in a worker bee. The test, however, proved that the work and flight capacity of the bee depends on the sugar content of the blood. The centre from which the sugar supply comes is the honey stomach. If this is emptied the bee is exhausted, it can fly only as long as it has sugar.

The function of the "Queen" is different from that of "workers" and tests of sugar content and activity must be made by other methods. *(Bentler)*

THE EDIBLE FROG IN ENGLAND

THE species of native Amphibia in England are so limited in number that some notes, and results of personal observation on the above, may be welcome.

Rana esculenta is doubtfully considered to be indigenous to this country, though it was well known in East Anglia throughout the last century. H. Gadow, writing the chapter on Amphibians in *Natural History of Cambridgeshire*, states: "The Fens of Cambridge and Norfolk seem to be the only districts in England which may rightly claim this otherwise continental species as indigenous."

Again, Thomas Bell in *History of British Reptiles*, 1849, states: "...I have often heard my father, who was a native of those parts, say that the croak of the frogs there was so different from that of the others, that he thought they must be of a different kind. It is somewhat remarkable that my father, who was no systematic naturalist, but a very accurate observer, should have detected when a boy, now more than

eighty years since, the distinction of this species of frog."

This evidence, though otherwise unsupported, takes us back to the middle of the eighteenth century, and is at least worthy of consideration. On the other hand, fossil remains are unknown, and it is well authenticated that numbers of the typical form were introduced into Norfolk about 1840, and that these thrived for a considerable time.

It is a little difficult to be certain of the present occurrence of this frog in Norfolk, and a letter dated 1930 from the Norfolk and Norwich Naturalists' Society informs me that they have no recent records of *Rana esculenta* in the county.

There would seem to be no physical or geographical reason which would exclude the edible frog from an indigenous status in this country. It occurs throughout Europe and as far north as Southern Sweden, with all the consequent variations of climate and temperature which this distribution implies. Ponds, dykes, canals, and the quieter reaches of slow-flowing rivers are its favourite haunts, and I would

The Edible Frog, Rana esculenta

venture to suggest that throughout rural and even suburban England there are numerous localities which would be very suitable for this amphibian.

Indeed, I go further, and submit as a direct result of my own experience that the edible frog may occur in places, and live out its life-cycle, in very ordinary yet unsuspected conditions. It may come as a surprise to some, to learn that the edible frog thrives and increases in at least two areas to which the public has access within ten miles of Charing Cross.

To what does it owe its continued existence in these localities? Are there factors of habit or environment which contribute to this noteworthy survival?

The edible frog is, at maturity, considerably larger than the common frog, the head tapers more sharply, the eyes are more prominent and closer together—indeed, the whole appearance is more suggestive of a wary alertness well borne out in actual fact. In the typical form the predominant colour is a bright green with a vivid yellow or blue green dorsal line extending the entire length of the back. The edible frog is more strictly aquatic than any of its congeners, and will but rarely be found on land more than two or three feet from the water's edge, to which safe haven it returns in one superb leap on the slightest alarm. This frog is peculiarly susceptible to the conditions of atmospheric pressure which prevail during the periods of summer thunderstorms. At such times it leaves the water in large numbers and scatters in all directions, crossing roads, and exhibiting none of its customary shyness of human beings.

The call note, which attains its most strident tone at the height of the breeding season, is a harsh two-syllabled sound rendered immortal by Aristophanes as KŌ-AX. The spawn is laid early in June, by which time the tadpoles of the common frog are nearly half-grown. It has been my good fortune to watch the actual spawning process. This spawn is definitely "raked" or squeezed out of the body of the female in small masses, by the action of the male's hind legs, and fertilized as it emerges. Consequently the spawn is found in small flat floating clumps, thus distinguishing it from the single large round mass of spawn of the common frog.

The edible frog provides an interesting example of the manner in which wild life may be present even in the London area without the knowledge of the general public. I had often passed by one of the ponds earlier referred to, and casually watched people fishing, and dogs swimming; then, one day I chanced to go at a time when I was the sole visitor. On approaching the pond's edge I heard a number of "plops" in the water—not simultaneously, but in rapid succession, round the edge. Nothing was seen, and no ripple stirred, but I had noted this peculiarity so frequently abroad that I was immediately interested. I waited quietly for about ten minutes, to be rewarded then by the sight of a large edible frog rising from the depths to float nervously on the surface. An involuntary movement caused him to disappear, but it was enough, and a theory had been proved. Subsequently, as the summer advanced, I was able to note the interesting natural protection resulting from the frog's habit of lying on the water surface, between the floating oval leaves of our native *Potamogeton natans*, whose general shape and venation tone so well in the distance with the exposed back of the amphibian.

From the foregoing experience one is perhaps justified in the thought that this handsome species may well occur elsewhere, and it may not be out of place to suggest that readers of *Discovery* may add practical interest to their country rambles, and provide useful data on the possible distribution of *Rana esculenta*, by careful observation on the lines indicated.

L. G. PAYNE.

Letters from Readers

Soil Elements and Plant Absorption

I WAS very interested in the account in the November *Notes of the Month* of the possibility of determining the presence of soil elements by analysis of the tissues of suitable higher plants growing in the soil. At the same time, I should like to point out the error in the statement that substances in solution in the "free" and "bound" soil water, are indiscriminately absorbed by the plant. Perhaps I may be allowed to elaborate this point.

Practically all the researches carried out on this subject have been on small flowering plants grown in culture solutions, but the results apply equally well to the larger, deep-rooted specimens with which the mineralogist would be concerned.

Dealing with metallic cations and the corresponding non-metallic ions (elements and radicals), there is direct experimental evidence of selective absorption on the part of the cytoplasm of root hairs. This property is usually vaguely attributed to the inner or tonoplastic "layer" of *living* cell cytoplasm, but it is something quite distinct from purely physical phenomena, such as osmotic diffusion, negative osmosis (due to electrostatic repulsions), the negative charge on the living protoplasm, boundary potentials, and the Donnan equilibrium. It is however very closely connected with that equally vague phenomenon, antagonism of ions.

The concentration of the ions concerned is also an important factor, and in the case of radicals and complex ions, the chemical nature of the ion, and the elements with which an essential element is combined, e.g. the essential element sulphur may be readily absorbed by a particular plant as the HSO_4^- or SO_4^{--} ion, but not as the HS^- ion or as an uncharged organic thiomolecule.

The mineral requirements of plants may be divided into two groups: (i) those

needed in relatively large amounts, and in which the soil may become deficient; (ii) those needed in small amounts and referred to as trace elements. In Group (i), potassium, calcium, magnesium and iron; and nitrogen, phosphorus and sulphur in radicals, are of interest to the mineralogist, and, in Group (ii), plants may help him to detect sources of aluminium, boron, manganese, copper, zinc, fluorides and iodides, and several others. On the other hand, selective adsorption, and ionic antagonism, may prevent his "plant indicators" disclosing a rich source of a particular mineral. There are several interesting examples of this. Rubidium, for example, can be taken up by some plants if present in the soil, but the very similar alkali element, caesium, is definitely toxic, and is never found in plant ashes. The trace elements appear to function either catalytically or in enabling the plant to withstand specific diseases. In the case of marine algae, it is well known that potassium and iodine ions are absorbed in far greater quantities than sodium and chlorine ions, although the ionic concentrations of the latter pair of elements in sea water are much higher.

The author of the *Note* may find the following accounts of recent research on cell surfaces and absorption of interest:

NEWTON, HARVEY & DANIELLI (1936). *Biological Reviews*, vol. 13, no. 14, p. 319.

LUNDEGÅRDH (1939). *Nature*, vol. 143, no. 3614, p. 203.

I. C. H. MAY, Southampton.

This letter was sent to the author of the note "A New Technique for Mineral Prospecting", whose reply is given below.

TO describe the absorption of mineral salts by plants as *indiscriminate* is perhaps open to objection, but I think your correspondent will agree that certain of the elements derived from the soil and found in plant tissues do not appear, at the present stage of our knowledge of plant physiology, to be essential for plant growth (e.g. selenium). The point which ought to be stressed in connexion with this technique of tracing minerals by detecting their constituent elements in the analysis of leaves of plants is that any element present in the plant tissues must have been derived from the soil. It is quite true that while all elements found in the leaves must have derived from the soil, the converse, that all elements found in the soil will be found in the leaves, does not hold.

W. E. D.

Experiments in Colour

AN interesting article on colour harmony by Miss Barne in the February issue decided me to embark on a little experiment. In her article Miss Barne discredited the idea that complementary colours are more pleasing than others when juxtaposed. It was not my wish to prove her wrong, but rather to attempt to establish some principles by a series of direct tests. These tests were made by presenting the subjects, twenty-four adults and twenty-one children, with eight sheets of paper 7 inches square, in yellow, orange, red, purple, ultramarine blue, turquoise blue, sea green, and leaf green. Wherever possible the papers were placed on a neutral surface, and always at random. Then the experimenter would select one of these papers and place it before the subject, who was asked to select by trial a paper from the remaining seven which he considered gave the most pleasing effect when juxtaposed to the paper before him. It was explained to him that he could place one paper over the other and manipulate them in any way he pleased, so as to adjust the relative areas of the two colours until the best effect was attained. The test was completed when the subject had selected a paper for each of the eight papers set before him in turn by the experimenter. Graphs were made recording the votes for each colour.

F. HUGHES SMITH, Scarborough.

Miss Barne's reply:

MR HUGHES SMITH'S experiments are very interesting, but would perhaps be even more so if one knew whether the adults had had any training in art matters; looking at good pictures and room decoration, etc. If they had *not*, the results are precisely what I should have expected; I myself, as a child, preferred such startling contrasts as are afforded by the juxtaposition of complementaries. Good taste is quite as much a matter of training as of predisposition, if not more so. The analogy with music comes in here: the most cacophonous jazz is easily endured—even, I believe, liked—by the uneducated (I mean of the richer as well as the poorer classes). Historically, I think, melody came long before harmony, and an appreciation of the latter is only found among the very highly civilized nations. Perhaps, after the war, we shall all go back to painting our walls crimson and hanging sea-green curtains on them!

MARY BARNE, Bloxham, Oxfordshire.

The Speed of Birds

IN your November issue Mr Winter says that a speed of 200 m.p.h. for the swift must be regarded as a flight of fancy. In India E. C. Stuart-Baker has timed the large spine-tailed swifts over a 2-mile course. The stop-watch readings varied between 36 and 42 sec. The speeds for the course, therefore, varied between 200 and 171·4 m.p.h.

Mr Winter quotes Meinertzhagen (than whom few men have done more to increase our knowledge of birds' speeds) as being distinctly dubious about a speed for a swallow of 106 m.p.h. If this were the only record of such a speed for this bird, the scepticism would be justified. Actually there are three other records which indicate that a speed in excess of 100 m.p.h. for the swallow is not an exaggeration. To quote but one of these other records: it was reported in July of this year from Italy that a swallow, taken from her nest to a point 79 miles distant and released, was home within 43 min.

Mr Winter says, "As far as is known the lammergeier holds the speed record for diving flight", and he gives a speed of 110 m.p.h. An aviator has related that when he made a nose-dive at some ducks, although his plane was registering 170 m.p.h., a (duck?) hawk passed him "as though the plane were standing still". The swoop of a peregrine (the English duck hawk) is often computed at 200 m.p.h.

Mr Winter appears to think the altitude record for birds is held by the lammergeier with a recorded height of 24,000 ft. An astronomer, while photographing the sun at Dehra Dun in India, obtained a picture of geese flying at an estimated height of 29,000 ft., and another authority claims that Egyptian geese have been observed at an estimated height of 35,000 ft.!

Mr Winter says that films made by a new type of camera with a shutter speed of 1/100,000th sec. (surely no shutter is capable of this speed—presumably spark photography is meant) proved that humming-birds can flap their wings at 200 beats per sec. Sorry, but I don't believe it. Films taken at 1200 pictures per sec. proved that, when hovering, a humming-bird beats its wings at 50 beats per sec. and when flying at 70 beats per sec. These figures have recently been corroborated by Dr Leigh Chadwick at Harvard.

Finally, Mr Winter says: "The endurance record surely goes to the golden plover, one species of which migrates from its breeding ground in Alaska to the islands of the Low Archipelago in latitude 20° south. This journey, performed each winter, involves at the lowest computation an oversea flight of 3000 miles." But what about the Arctic tern! To quote *Natural History* for October 1939: "The longest flight on record is that of an Arctic tern which travelled approximately 9000 miles, from Labrador to South Africa, in less than 90 days. This champion migrant nests in some places within eight degrees of the

North Pole, yet during the northern winter it is seen in the South Atlantic and even below the Antarctic Circle."

FRANK W. LANE, Ruislip.

We sent this letter to Mr Winter, the author of "The Speed of Birds". His reply is printed here.

I AM always anxious to add to my aeronautical knowledge, so it was with interest that I received Mr Lane's letter. Unfortunately, a perusal of it is most disappointing, since the letter lacks just those details which are essential in the determination of any record. It merely bears out my remark "that it is most rare to find any statement of the method of measurement employed (if any) or an account of the meteorological conditions prevailing at the time of the observations".

Any method of measuring flight speed which does not take into account both the speed and direction of the wind is valueless. In none of Mr Lane's records is any mention made of these vital factors.

There is reference to two diving "records". Nothing is said of the angle at which "an aviator" saw the duck hawk pass his plane, which would have been most helpful. Mr Lane's statement that the speed of the peregrine "is often computed at" 200 m.p.h. shows that very lack of definiteness which I so often encountered in my own researches.

A similar lack of certainty is shown in his remarks about height records, for in his own words both of his examples were merely "estimated".

In his last quotation from my article Mr Lane has confused an *endurance* record which I had selected with a *distance* record. No one with any knowledge of bird migration could possibly think that a distance of only 3000 miles could constitute a record. What I wrote was than an *oversea* flight of not less than 3000 miles formed part of the migration flight of the golden plover. It is obviously the oversea hop which constitutes the endurance record.

As for the reference to the wing beats of the humming-bird ,Mr Lane states that he does not believe the figure given. I am sorry for this, but naturally Mr Lane's beliefs do not alter the facts.

H. T. WINTER, M.I.Ae.E., Writtle, Essex.

Adhesives and Electricity

ON unwinding some black insulating tape in the dark, I observed that a light was produced at the line where the coils separated. For a particular specimen, the intensity appeared only dependent on the power used in unwinding, at the instant, and disappeared immediately the unwinding ceased. A similar but fainter effect was observed with "zinc oxide" antiseptic tape. What is the substance responsible for the (apparent) energy conversion?

K. N. CHANDLER, Southport

Methods of Pest Control

RECENT experiments carried out in Russia indicate that bacteria and fungi which are naturally parasitic on insects may be used to control pests in a manner analogous to the ichneumons, brachonids and other parasites which are important instruments of "biological control".

An example of a commonly occurring bacterial disease of insects is the "European foulbrood" of bees, though this of course "controls" a useful insect to man's disadvantage. The disease has been traced to a specific bacterium, *Bacillus pluton*, which infects and kills the young larvae. It is most lethal in weak colonies early in the breeding season.

Attempts to control insect pests by the artificial dissemination of pathogenic bac-

teria have been made a number of times with varying degrees of success. As early as 1912 d'Herelle infected the Mexican cricket with pure cultures of *Coccobacillus acridiorum*. The bacteria were applied to the food plants of the insect, and infection was through the mouth. He claimed positive results by this method in Mexico, Argentine and Tunis. Other workers, however, who tried his method did not achieve the same results.

But Metalnikof and Chorinc in 1929 found that when the European cornborer (*Pyrausta*) was infected with *Bacterium thuringiensis*, 50 % of the insects were killed off. This method was repeated by Bela Husz, who obtained the same lethal efficiency.

The same bacterium, generally called Metalnikof's bacillus, is now being tested in Russia for controlling the various caterpillars found on cabbage plants. Cultures of the bacillus are grown on alkaline potato agar. In 10 days the cultures are covered with spores which are easily detached and concentrated away from the culture by washing with water. Potato flour is then added to the spore-laden washings, and when the mass of flour and spores has dried it can be reduced to a powder in a mortar. This is then dusted on to the cabbage plants like derris or pyrethrum powder, or it can be mixed with water and sprayed on like any other liquid insecticide. When dusted on, from 25 to 90 % control is obtained. When applied as a liquid spray between 70 and 100 % of the insects are killed.

In nature, fungi which are parasitic on insects no doubt play a part in controlling "the balance of nature". In general such outbreaks of disease due to fungi appear only when the insects occur in abnormally large numbers.

But field workers have found it well nigh impossible to spread an epidemic of a pathogenic fungus when it does not appear naturally. It also seems certain that once a fungus attack has started, it cannot be intensified by human interference. The intensity of the attack appears to be influenced by controlling factors such as temperature and humidity which cannot be affected by human agency. The most favourable condition for the spread of the fungi are a wet autumn and winter, succeeded by a dry spring and summer.

Most of the fungi which are important instruments of natural biological control of insects are members of the group known as the Fungi Imperfecti. It is with these fungi that attempts at artificial biological control have been made.

Metarrhizium anisoptiae has been used against sugar-cane hoppers and the rhinoceros beetle, which attacks coconuts. (This fungus is closely related to the fungus which causes the disease of silkworms known as "muscardine".) An attempt to control the coffee pest of Java, known as "green bug", was made with the fungus *Cephalosporum lecanii*, but without success.

In Florida the "red fungus" (*Ascheisonia aleyrodes*) and the "yellow fungus" (*A. flavo-citrina*) were used against the white-fly (*Aleyrodes citri*). In nature it is estimated that these fungi kill off as many as 66 % of the insects. Attempts to increase the kill did not succeed, but the fungus appeared to help when it was introduced into groves where it did not occur.

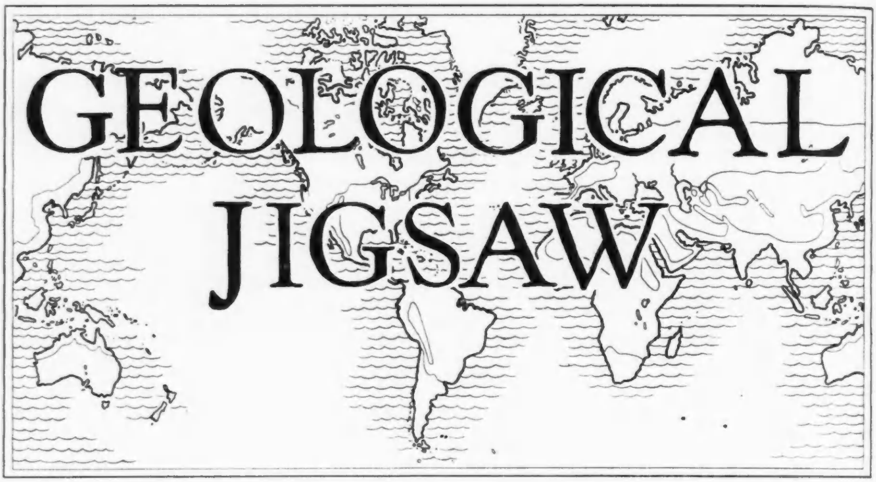
The chinch bug in America is controlled in wet seasons by the "grey fungus" (*Empusa aphidis*) and also by the "white fungus" (*Sporotrichium globuliferum*). Attempts to intensify this natural control have not proved successful.

In experiments carried out by Russian workers recently mortalities up to 85 % are claimed, however, for the fungus *Beauveria bassiana*.

W. E. D.

INVITATIONS TO KNOWLEDGE. X

GEOLOGICAL JIGSAW



Geology shows that climatic conditions on the earth have been continuously changing. One attempt to explain climatic change is the theory of continental drift. This article gives an outline of this theory and some of the evidence in its favour.

MODERN geology has succeeded in constructing a most ingenious and trustworthy time-machine for observing the world's past. Ink-written records tell us something of humanity's recent doings but virtually nothing at all concerning its larger home, the earth, where history is so long that Euclid and Einstein, Menelaus and Mussolini, become almost contemporaries.

The materials from which the new geological time-machine has been fashioned are the common rocks and stones under our feet. Every bit of ground, each dredging of mud and ooze from the sea floor, each one of the myriad different rock formations enables us more or less clearly to reconstruct the life and scenery and climate that prevailed somewhere sometime during the eventful evolution of the globe we live on. The clay, for instance, through which run London's tube railways, lets us look back into a remote and remarkable antiquity and see an important bit of Britain as it used to be nearly fifty million years before the coming of man. It shows us the ancestral Thames, incomparably bigger and warmer than now—a great tropical river winding its way through wholly un-English-like tropical jungles, alive with unfamiliar tropical animals, and burnt beneath turquoise tropical skies.

This fantastic, hard-to-be-believed picture is nevertheless a perfectly true one; it faithfully represents early Tertiary London and district, that is to say, London and district during the early Tertiary or Eocene period of the Earth's geological history. Set against the same scene to-day, the greatest of all cities, the hurrying millions of humans, the miles of bricks, the roar of mechanized transport over paved highways, the smoke-fogs and chill grey skies—could any contrast be more spectacular? How

does this London Clay, as it is called, reveal these things? Chiefly through its fossil content. The relics of the primitive tropic animals are in it—the teeth and bones and shells of crocodiles, tortoises and corals. The relics of the primitive tropic jungles are there too—the trunks of cone-bearing trees, the nuts, leaves, and seeds of plants native to balmier shores than ours; the fruits of the Nipa palm are unusually plentiful. The banks and broader bed of the former river are plainly visible at points, while the limits of the greater Thames estuary are, to trained eyes, well-defined in the composition and disposition of the bedded rocks.

Now this very ancient Britain was not alone and specially favoured in being a land of eternal summer. On the contrary, the early Tertiary age was one of exceptional and widespread warmth. Even the polar regions were largely ice-free. Sunshine and calories were almost everywhere, frost and snow nearly nowhere. Not for the first, but for the last time, the world had become something of a garden of Eden before Adam (this was no short-lived paradise either; it lasted certainly 1000 times, and probably 5000 times, as long as the entire Christian era). The proofs are as numerous and interesting as they are instructive and convincing. Well over 120 species of fossilized beech trees, poplars, chestnuts, plums, vines, sequoias, and such like have been dug from the land where the mountains of Greenland are to-day, where late summer often brings 70° of frost. Let us remember here that 10° of frost is a cold winter spell in Britain. The vegetation of Greenland at the present time is, by comparison, hardly worth mentioning; it is sparse and stunted and short-lived, and Greenland itself, for at least nine months out of every twelve, is just one big barren snowscape—a vast wedge of solid ice nine times the area of Britain and more than a mile thick down the middle.

Again, in Spitzbergen, an intensely arctic country only 700 miles from the north pole, Eocene rocks have yielded abundant fossil remains of oaks, poplars, limes, and hazels. The mean annual temperature there now is 14° F. *below* freezing point (the mean annual temperature of England is 18° F. *above* freezing, or 50°), and the ground hardly anywhere thaws below a depth of 7 or 8 in. even in summer. To find such a vegetation to-day one must travel nearly 2000 miles to the south where the mean annual temperature reaches about 48° F. Experts hold that Greenland and Spitzbergen must then have been warmer by at least as much as London in July is warmer than London in January, namely 24° F. Luxuriant Tertiary forests, now buried, crushed, and decayed into coal seams, flourished on desolate New Siberia Island, far within the Arctic circle and to-day one of the most icy, inhospitable spots on the globe. The

Wegener's theory supposes that the primitive continents were packed together to form continuous land

(*From Jeans:* Through Space and Time)

most northerly of all mineralized plant remains were discovered less than 600 miles from the north pole. They consist mainly of elms, hazels, conifers, water-lilies, and giant swamp-cypress, plants that will grow only in climates of 46° F. or warmer. Yet their relics were unearthed at a place fully 50° colder than this, i.e. at perpetually frozen, completely uninhabited, Grant Land, to the far north of Quebec, whose climate averages 4° below zero—36° of frost.

southern England; here we have some very typical pieces of a first-class geological jigsaw, and we naturally come to ask how Nature contrived to play such climatic pranks upon the old, old, earth. Geologists have still to answer this question decisively, but their most recent and promising attempt to do so may be worth outlining because it ranks as one of the most novel and epoch-making contributions ever made to a major science. It is to be found in the Theory of Continental

Layers o, black slate and limestone at the south-east end of the island of Kerrera, off Oban, showing crumpling and folding. The geological hammer on the left shows the scale. The same process on a much larger and more complex scale produces great mountain chains such as the Alps or the Western Cordillera of the Americas

(*From Jeans:* Through Space and Time)

Geological Museum

The mute bearers of these dramatic tidings from long ago are sometimes more beautifully preserved than the mummies of the Pharaohs: petrified tree stumps standing erect with petrified roots still embedded in the petrified primordial soil they once grew in: complete leaves pressed flat yet with their delicate veining clearly visible suggest specimens just taken from a botanist's herbarium: detailed impressions of ears of maize and even the actual grains themselves within the heart of old, solidified lava. Such are among the stone specimens to be seen in Nature's underground museum. A green and genial Spitzbergen contemporary with a mild, forest-clad, Greenland, and a winterless, hot-house

Drift, particularly as it was developed and formulated by Professor Alfred Wegener in 1916. Incidentally, the recently published narrative of the adventures and untimely death of this famous German geologist in Greenland a year or two back is one of the most thrilling and tragic in the annals of exploration.

For excellent and various reasons, the continents of the world are now generally regarded as great granite "rafts" floating upon a softer under layer or sea of heavier, semi-molten, lava-rocks known as the substratum or magma zone. Being thousands of miles in both length and breadth, and probably less than 30 miles thick, the continents have been rightly compared to

floating and drifting rafts rather than to ships or icebergs. Their excessive thinness or lack of depth should render them relatively fragile and liable to breakage. Professor Wegener claims that such breakage has actually happened, not once but often, and, what is more important, that continents and oceans are ceaselessly moving over the face of the Earth both with respect to each other and to the poles; the continental "rafts" are now near the pole, now in the temperate zone, now astride the equator.

Madagascar as a piece that broke off and lagged behind. India similarly calved off Ceylon in the general westerly migration, while the equator, also getting restive, slid steadily towards its present position nearly 3000 miles away to the south. Later on, Eurasia, creeping south, crashed head-on into Africa, India, and Australia as they moved north, the terrific impact crumpling up the opposing continental frontiers into the great mountain system and spine of the Old World—the Alpine-Himalayan. This includes the Pyrenees, the Alps, the Caucasus, the Atlas of North Africa, the Himalayas, and also the East Indies, Borneo, Java, and neighbouring islands which are really nothing but the unsubmerged summits of equally lofty marine mountains.

Diagram showing how simple fold mountains are formed by horizontal movement

The Wegener hypothesis ascribes the tropic weather and vegetation of early Tertiary England to the simple fact that our country at that time was actually within the tropics and only some 600 miles from the equator itself which then passed through the south of France and northern Italy. The early Tertiary period saw the Earth's surface consisting of but one stupendous ocean and a single super-continent made up of all the present day continents and islands rolled together. The warm waters of the tropics had direct access to the Arctic and Antarctic regions, which minimized the formation of ice-caps. Ocean currents were able more efficiently to distribute heat to the world and so it enjoyed a more uniformly mild climate. Presently, the great parent land-mass began to disintegrate. Preceded by fracturing and fissuring on a giant scale, South America fell away from Africa, and, drifting slowly westward, opened up the South Atlantic Ocean. Africa, following suit though still more slowly, left behind the island of

Rebounds and after-shocks sundered Africa from Arabia and Asia, and caused, by tension (stretching) and collapse, a quite extraordinary system of mammoth natural trenches of a type found nowhere else in the world. These long narrow down-sunken trenches or canyons run interruptedly from the river Jordan in Palestine to the Zambesi in Africa, over 4000 miles away. Some are a mile deep and constitute the well-known "rift-valleys" of East Africa, while others hold the waters of the Sea of Gallilee, the Dead Sea, the Red Sea, and such well-known East African lakes as Rudolf, Nyassa, Tanganyika, etc. This heroic earth-storm and scrimmage culminated in North America working loose from Europe and veering mainly south-west. The first big

lump to be shed en route was Greenland. Further and more severe shattering, due to distension behind, resulted in the formation of the Arctic island group to the north of Canada among which are Baffin and Ellesmere Islands. This sensational finale is thought to have ceased only 5 min. ago, geologically speaking, which means a few hundreds of centuries or so.

Hardly less startling than the hypothesis itself is the real possibility of its being substantially true and justified. The array of geological and biological facts on which it has been founded is significant and impressive. Space allows of only one or two of these being mentioned here. Examine an atlas. You will find that the fjord-indented coasts of Greenland and Norway which face each other are curiously alike; they would, in fact, make a good join if brought together. The west coast of Greenland would fit admirably on to the east coasts of Labrador and Baffin Island. There are numerous other instances but the most arresting coastal congruence of all is probably that of Africa and South America which Professor Wegener used as the starting-point for his far-reaching theory. In many cases, the rocks, fossils, and direction of mountain chains emphatically support the surmise that now widely separated lands were formerly united.

The poles of the earth not only *can* shift their position—they *do*. This became an established fact as far back as 1891, and actual measurements show that they regularly roam over an area about the size of a cricket pitch. We may not have budged an inch, but our cities and ourselves are all a few yards farther north or south to-day than seven months ago. Text-books refer to this as the fourteen-monthly variation of latitude.

The epoch during which the one big Wegenerian continent is said to have broken up, was unquestionably one of the most fateful and tempestuous for the Earth since she solidified. Then it certainly was that the grandest physical revolution and mountain-building episode in 1000 million years transformed the whole face of the globe. Greater Britain, twice its present size and stretching beyond Ireland out into the Atlantic, became shattered by irresistible subterranean movements which gave rise to the "greatest volcanic eruptions these isles have ever been through, and ones that extended from pole to pole".* The 40,000 pillars of the Giant's Causeway and most of the Scottish Hebrides were then molten lava flows. The major mountain ranges of the world were one and all upraised during this same critical and astonishing period, the mid-Tertiary, which dates back roughly thirty million years or so. Moreover, the structure of nearly all mountain ranges proves them to be due not to simple uplift or vertical elevatory movements, but chiefly to lateral or horizontal compression. They consist essentially of rock-strata which have been smashed and crumpled like strawboards into folds and overfolds, and, in places, positively twisted and tied into mountain knots of excessive, indescribable intricacy. The colossal collision of Eurasia with Africa, India, and Australia would supply just the compressive force needed to crush and upsqueeze the rocks of the Alpine-Himalayan mountain system. The extent and direction is just right, too, for the system runs tolerably parallel and near to the line of impact along an 8000 mile front. It is interesting to note by the way that the folding and upsqueezing of the mighty Himalayas is estimated to have shortened the distance between India and Siberia by as much as 400 miles.

The outstanding physical feature of the American continent is the almost unbroken mountain chain which runs right down the entire length of its western or Pacific seaboard. This includes the Rockies and the Andes. A comparatively rapid westerly drift from Europe seems at present a most likely agency to produce this remarkable 9000 mile rocky backbone of a vast

* Professor W. W. Watts, President of the British Association in 1935.

continent. Such a drift would lead to crumpling and ridging-up (mountain-building) along the advancing western margin (the Pacific coast), and to stretching and probably snapping off of islands at the rear (the east or Atlantic coast). The physiography of the New World is in fact as if just this had actually happened.

J. ROBINSON.

Reviews of New Books

Astronomy

THE authors of this work* are well qualified to produce an astronomical treatise that will be both up-to-date and also interesting reading to students of astronomy as well as to the general public. W. T. Skilling has devoted many years to the teaching of astronomy, while R. S. Richardson is working at the Mount Wilson Observatory where he is engaged in the specialized branch of solar research. After a brief description of our own planet, a chapter is devoted to an explanation of the various systems of co-ordinates in use, the ecliptic, equatorial, horizon, and the galactic systems, and this is followed by an excellent account of the equipment of the modern astronomer. The description of the various instruments in use for research in different spheres is very lucid, and can be followed by readers who are interested in the subject but who are not conversant with the details of optical instruments. Ten chapters follow which deal with the bodies of the solar system including comets and meteors. In addition to the descriptive portions of these chapters, two of them, VI and IX, give an account of the Calendar and of the tides, respectively. The latter will prove very helpful to those who are not in possession of an extensive mathematical equipment but who will nevertheless find the method for deriving quantitative results easy to follow. In the last four chapters the authors leave the solar system to consider stars and nebulae, and the results of all the most recent research are embodied in this very wide field. Many abstruse matters are clarified by the authors, and subjects that often present difficulties are set forth in a lucid manner.

* *Astronomy*, by William T. Skilling and Robert S. Richardson. Chapman and Hall, Ltd., 15*s*. net.

One feature of the work is worth noticing as it will assist the student in applying his reading of the text. At the end of each chapter there is a series of questions bearing on the particular subject dealt with in the chapter, and working out the quantitative results will be a very useful exercise for readers. As answers are supplied, the accuracy of the computations can be checked.

Naturally in a work of this description it is difficult to avoid minor errors, and the following may be noticed, with the reminder that there is no implication that the list is complete:

Page 28. The story that Newton was delayed in proving the inverse square law because he did not know the true size of the Earth is repeated, but this story is open to some doubt. This matter is dealt with in Professor F. Cajori's *Newton's Mathematical Principles* (Cambridge University Press, 1934), in the "Appendix". Mr J. Miller also shows how improbable the story is (*Journal of the British Astronomical Association*, L, 2, 1939 December).

Page 32, line 12 from the foot. For 300,000,000 read 3,000,000,000.

Page 299. Doubt is expressed about all comets belonging to the solar system, but it is certain that no comet has been observed to move in a hyperbolic orbit unless thrown into such by planetary perturbations. On pages 374–5 this is admitted.

Page 369. Comets Brooks and Lexell are described as "Brook" and "Lexel".

On page 560 certain Astronomical Constants are given. Where these are in miles it should be remembered that the American mile differs very slightly from an English mile, and confusion may be avoided by noticing this fact. The difference is about 1 in 300,000, the American mile being the longer of the two.

M. D.

Dinner for Nothing

Caliban lived without tillage on what the earth afforded, but lived on a magic isle, and there was some doubt, according to Stephano and Trinculo, about his proper humanity. Here in England, with our sloes, crab apples, earth nuts, frogs, snails, and rabbits, there seems small chance of a good wild diet. That, however, need deter nobody from using and enjoying Mr Jason Hill's book; * for to go foraging, and to get something for nothing, are two good pleasures. This little book tells you not only how to do these things, but how to cook the wild produce. "It is true", he writes, "that not many of the wild foods have a high nutritive value—if they had they would not be wild—but most of them are very rich in vitamins." That is a magic word in these days, and will work its effect on its devotees. Mr Hill mentions vitamins no more, and I think it is clear that adventure, a pleasure in the unusual, and a liking for new flavours are his real motives. Twenty-four wild plants of roadside and meadow begin his list. You can put lady-smock into sandwiches and salads, make something better than spinach out of young stinging nettles, use sorrel instead of vinegar in your salads, and can even eat without harm and some malicious pleasure the ground elder accursed by gardeners.

Five seaweeds are listed, of which Laver, a filmy reddish purple sea-weed, is said to be one of the great delicacies among wild foods. It is comforting at first to learn that there is only one lethal fungus in this country (*Amanita phalloides*) but disturbing to learn further that it is one most easily confused with the Field Mushroom itself. Mr Hill gives six recommendations only, and the essential very clear directions for identifying these. Of wild fruits more is already known, but one would like to try pickled ash-keys (said to taste like walnuts), Crab Apple Tea, Mountain Ash Jelly, and Salted Beech Nuts. The book deals further with creatures, animals, birds, and molluscs. "Grey Squirrels are said to be good *en casserole*", and Garden Snails can be nutritious. The recipes are preceded by three pages of warnings and rejections, where the reputation of roasted acorns as a substitute for coffee is denied. Of the recipes, as read, a personal choice seizes upon Tansy Pudding, Hazelnut Bread, Candied Sweet Cecily Roots, and Burnet Vinegar, and a dish of Country Soup. This book is recommended to adventurous young newly-weds, and country housewives with weekend parties of the right sort. Mr Jason Hill has tried all that he recommends.

* *Wild Foods of Britain*, by Jason Hill. Black, 2*s*. 6*d*.

Plants with Personality

Here is one of them: "It is a gigantic and monstrous aroid and grows at an incredible rate, sometimes six inches a day until it opens at a height of eight and a half feet. The mature inflorescence is said to give off an offensive scent resembling the smell of decayed fish." It would be unfair to call this typical, but Mr Synge has certainly a leaning towards the exotic ("in the best sense", he would add). His "personalities" are often of the Hollywood brand, that stick out a mile and dig you in the ribs until you notice them. His book* includes (of course) the world's biggest flower, and the plant with the biggest leaves; and his series of chapters on Insectivorous Plants, Fly-pollinated Plants, Gigantic East Africans and Fierce Wonders from Chile make poor *Iris stylosa* and *Crocus Imperati*, tacked unhappily to their tail, seem thin and homely. But this bias is largely conditioned by Mr Synge's own experience as a collector—in Borneo and East Africa—and by his garden, whose hot and sandy soil rejects not only *Meconopsis*, *Rhododendron*, *Primula*, *Lilium* and *Nomocharis*, as he admits, but all the Temperate beauties.

Granted the flamboyance of the subjects, their portraits are skilfully and attractively painted—in illustrations as well as in text, for the metallic quality of so many of these exotics (e.g. *Puya*) suits both Thornton's draughtsmen and John Nash. Mr Synge writes as a botanist of wide knowledge (let us debit "teraxicifolia" and the derivation of *Ipomoea* to the printer) and, to judge from his successes, as a skilled plantsman. He is obviously an admirer of Farrer, and has something of Farrer's infectious enthusiasm and gift for similes that both tickle and illuminate—the winter jasmine flower as a "savoury" is good. Unfortunately he has not the agility to carry off what he calls "Farrer's oriental voluptuousness". Farrer would be one minute prostrated before *Eritrichium*, the next up and capering in an uproarious war-dance over some unfortunate of the cress tribe or the misdemeanours of Customs officials. Mr Synge's occasional rhapsodies are unrelieved, and painful; but, unlike Farrer's, they have nothing to do with plants, and can be skipped—as can the Introduction. The book remains a real Invitation to Knowledge for the not-too-inexperienced gardener, especially if he is of the inquisitive and ambitious kind. For the scientist there is no discovery here; many of the plants were introduced over a century ago, and the least familiar, those found by Mr Synge himself, have already been described elsewhere. R. W. D.

* *Plants with Personality*, by Patrick M. Synge, Lindsay Drummond, 12*s*. 6*d*.

Puya Alpestris

One of John Nash's drawings in Plants with Personality

Captain Cook

The illustrious Captain James Cook has been the subject of many biographies and his exploits worthily fill many volumes. But this new biography,* written by a man both surgeon and seaman, stresses to advantage that side of Cook's work which so many forget in their interest in his exploration. Cook was a maritime dietitian and ardent experimentalist, despite his position in that essentially traditionalist institution, the British Navy. For reasons both of humanity and efficiency Cook, the surveyor, scientist and exploring naval officer, set out to save his men from scurvy, which in the eighteenth century, and much later, was the awful companion of all long voyages. At the time of Cook's voyages the essential fact, that fresh fruit and vegetables were both a preventative and cure for scurvy, was becoming widely known. Lind, the physician of Haslar Hospital, had, in particular, written extensively on the subject, but the normal ship's officer was slow to appreciate the value of this work. James Cook was different. In those days, 150 years before the concept of avitaminosis had emerged, he was almost unique in making every possible use of the knowledge that was available to his generation. He was tireless in his efforts to improve the seaman's lot by dietary experiment and an insistence on cleanliness. His success was unprecedented: he kept at sea on occasion for 5 or 6 months on end without a single case of scurvy. In his efforts he even went so far as to flog a man for refusing to eat the vegetable food that he knew to be essential for the man's well-being. All this is described by Admiral Muir who brings to the reader in a vivid way the wretchedness of the conditions under which the ships' crews were forced to live.

Though the author lays particular stress on this aspect of Cook's life and voyages, the whole makes most interesting reading. The reviewer has sailed the Southern Ocean as one of sixteen men crowded into an 100 ft. schooner on a voyage of exploration. To him and others one of the chief interests of this book lies in the renewed realization that the *Endeavour Bark* was scarcely larger, yet when she set out on the Transit of Venus expedition in 1768 she had a complement of 94 persons, including the young Sir Joseph Banks and his nine satellites. How the men were carried almost defies imagination.

A map, based on one published in 1787, is provided to show the ships' tracks on the three great voyages. The inclusion of a modern world map would have been an advantage since the 1787 map shows longitudes east from Greenwich, while the normal notation is used in the text. In a few places some will be a little irritated by the slightly "told-to-the-children" style of writing, but taken as a whole this biography is a well-written descriptive work that clearly brings out the many sides of Cook's genius.

G. C. L. BERTRAM.

* *The Life and Achievements of Captain James Cook, R.N., F.R.C.S., Explorer, Navigator, Surveyor and Physician*, by Surgeon Rear-Admiral J. R. Muir, M.B., F.R.C.S.E. Blackie and Son, Ltd., 10*s*. 6*d*.

Polar Exploration

A. & C. BLACK are producing a series of volumes entitled "Epics of the XXth Century" each "written from personal experience of a particular branch of exploration and adventure...." As stated by the publishers the aim of the books is to "show that the Elizabethan spirit lives to-day...." This is an admirable aim. Now, to succeed, any book must be written for a particular class of reader whether that class be limited or large. It is in this respect that Andrew Croft's book* falls short of expectations, a shortcoming which one suspects derives from the publishers rather than from the author. The style throughout is simple and direct, well suited to the VIth form boy, though for his proper appreciation having too little of the epic about it. To the older reader, not equipped with special knowledge, the paucity of descriptive passages will pall, though the second, or Antarctic half of the book is by far the better from this point of view. The result is that the book will be valued most by those already with considerable knowledge of polar matters, and they will prize it for its convenience and accuracy as a summary of effort in high latitudes.

The book is divided into two halves, covering Arctica and Antarctica, each half opening with an historical introduction and followed by five or six chapters on the main expeditions. Descriptions, opinions and explanations are scarce, and it is this reduction to basic facts that both hides the epic quality of the original work, and enhances the value of the book as a convenient summary. The photographs are excellently reproduced, but some of the very best have no author's name attached: they are by Andrew Croft himself. Errors of fact are rare though naturally there are one or two: for example, on page 3, the discovery of Bear

* *Polar Exploration*, by Andrew Croft. Epics of the XXth Century. A. and C. Black, 7*s*. 6*d*. net.

Island by Barents is given as 1586 which is just ten years too early.

So it comes about that here we have a book that is to be highly recommended as a convenient summary of facts, but which will give to few the true thrill of the polar epics of the XXth century.

G. C. L. BERTRAM.

Cosmic Rays

FOUR years ago, reviewing *Electrons, Protons, Neutrons and Cosmic Rays*, I ventured to express the hope that Professor Millikan might some time find opportunity to supplement his larger book of that title by a separate account of his own experiments and his own opinions concerning the cosmic rays—and I further ventured the suggestion that the form of the account should not be determined by the requirements of a popular text, but rather by the needs of serious students of physics. In the present volume* Professor Millikan has done better than this: he has given us what is essentially a popular exposition (for it represents the essence of public lectures given at the Universities of Virginia and Dublin on various occasions), and at the same time he has provided honours students in physics with an introduction to the subject which is both clear and exhaustive. The interest of such students cannot fail to be excited by the remarkable reproductions of cloud chamber photographs to be found in great number throughout the book, and their understanding of a very complicated phenomenon is sure to be greatly facilitated by the free use of graphical methods in the presentation of results. They will not, perhaps, be greatly moved by the first short chapter, which is more directly addressed to the popular audience than to themselves ("If one is capable of [being sufficiently discriminating] and willing to [be sufficiently patient], then I have the greatest sympathy with the question 'What are cosmic rays good for?' and I am going to spend a certain fraction of this hour trying to answer it," p. 2), but they will certainly see in the rest of the book an illustration "that Science has found a method by which truth can be discovered and error in time destroyed" (page 24) and a warning against the fallacy of the dictum "that one opinion is as good as another" (page 24). Indeed, the rest of the book contains many confessions such as "From our point of view . . . this discovery was important because it showed that another element in the interpretation which we had thus far placed on cosmic ray phenomena was wrong" (page 72). These are altogether healthy signs, for the subject of cosmic rays has been one of frequent surprises in the last ten years.

Professor Millikan's account has been brought up-to-date to the spring of 1939, and it is sufficiently well documented to make further study attractive. It mentions casually, at least, all the chief workers both in and out of America in the experimental field, but—in respect of one small point—it is surprising to find that it discusses the nature of the positive electron without any explicit reference to the theoretical work of Dirac, some of which preceded the experimental discovery.

N. FEATHER.

* *Cosmic Rays*, by R. A. Millikan. Cambridge University Press, 8*s*. 6*d*.

Nature Parade

This is just the book* we need for 1940. To know that ants can make biscuits, that a dragonfly can fly at 55 miles an hour and a hippopotamus can run 8 miles per hour under water, will do us all good in a generation when we are so mighty proud of our own achievements. The description of the ingenious method adopted by driver ants to cross a river in a solid body is splendid; it makes me wonder whether ants, clever and sociable as they are, would ever have brought their community to the pretty mess man finds himself in to-day. Many books written on the marvels of nature run away with themselves, but in *Nature Parade* the author keeps a firm hand throughout on any chronicles open to doubt; when he includes such mysteries as the Loch Ness Monster and the Abominable Snowman he is as much the scientist as when he writes of the blue whale developing 500 horse-power at 27 knots.

How many naturalists will agree with the author that if you put a great tit in an aviary "by the morning all its companions will have been scalped, and the little fire-eater will have feasted on their brains"? With good reason the great tit has earned a reputation for pugnacity, but he is no mass murderer. I have kept great tits in company with blue tits, chaffinches and house sparrows without a single fatality. This year I had three great tits (two males and one female) in an aviary with seven house sparrows and one hedge sparrow for a fortnight, and when I released the eleven birds, every one was in perfect condition. Nor a single fight had occurred. And surely no hedgehog can "run almost with the speed of a rabbit"? Old hedgehog can certainly foot it neatly when he is so minded, and can cover two or three miles in a night; but if the rabbit's speed is 35 m.p.h. the hedgehog would on all occasions be an also-ran. Although I have studied many dozens of

* *Nature Parade*, by Frank W. Lane. Jarrolds, 15*s*.

hedgehogs intimately I have not yet met one which could outdistance me, even when he was apparently going at top speed.

The book is magnificently illustrated by photographs, those of animals and birds at speed being exceptionally fine. The arrangement of the chapters is novel. The first section, Private Lives, has chapters on Food, Toilet, Sleep, Leadership, Strength and War; while the second section, Speed and Locomotion, is conveniently divided into Animals, Fish, Birds, Insects and Out of their Element. Then comes Section III, Animals we never see Alive, which is about rare and "mystery" animals. The careful Index is welcome, permitting the reader to turn in a moment to the turkey, the tunny or the tufted puffin, and find what those creatures can do in their own element.

PHYLLIS KELWAY

Select List of Books Received by *Discovery*

(*Mention in this list does not preclude review*)

The Physics of the Divining Rod. J. C. MABY, T. B. FRANKLIN. (Bell, 21*s.*)

Deep Water and Shoal. WILLIAM A. ROBINSON. (Travel Book Club, 3*s.* 6*d.*)

The Theory of Probability. HAROLD JEFFREYS. (Oxford, 21*s.*)

Mr Tompkins in Wonderland. G. GAMOW. (Cambridge University Press, 7*s.* 6*d.*)

Prelude to Chemistry. JOHN READ. (Bell, 12*s.* 6*d.*)

Metallurgical Analysis and Assaying. J. STEWART REMINGTON and F. L. JAMESON. (Technical Press Manuals, 5*s.*)

Teach Yourself Economics. S. E. THOMAS. (English Universities Press, 2*s.*)

Teach Yourself Geography. J. C. KINGSLAND and W. B. CORNISH. (English Universities Press, 2*s.*)

A Camera in the Hills. F. S. SMYTHE. (Black, 12*s.* 6*d.*)

You and Life. Professor KARL VON FRISCH. (Scientific Book Club, 2*s.* 6*d.*)

Modern Man in the Making. OTTO NEURATH. (Secker and Warburg, 16*s.*)

Biology of the Vertebrates. Revised ed. H. E. WALTER. (Macmillan, 21*s.*)

The Story of the British Colonial Empire. DOUGLAS WOODRUFF. (H.M. Stationery Office, 2*s.* 6*d.*)

Why we had to go to War. ARTHUR MEE. (University of London Press, 2*s.* 6*d.*)

Modern Armaments. Professor A. M. LOW. (Scientific Book Club, 2*s.* 6*d.*)

Tuberculosis and Social Conditions in England. P. D'ARCY HART and G. PAYLING WRIGHT. (National Association for the Prevention of Tuberculosis, 3*s.*)

IN accordance with its usual practice Trinity College, Cambridge, announces the offer of a Research Studentship open to graduates of other Universities who propose to come to Cambridge in October next as candidates for the degree of Ph.D. The value of the Studentship may be as much as £300 a year if the pecuniary circumstances of the successful candidate require so large a sum. Candidates must not have reached the age of twenty-six before 1 May 1940. In certain circumstances an election may be made to an additional Studentship.

The same College offers, as usual, Dominion and Colonial Exhibitions to students of Dominion and Colonial Universities who wish to come to Cambridge next October as candidates for the degree of B.A., M.Litt., M.Sc. or Ph.D. These Exhibitions are of the titular value of £40, but their actual value is such sum (if any) not exceeding the titular value as the College Council may from time to time hold to be justified by the Exhibitioner's financial circumstances. If it is made clear that the financial need of an Exhibitioner cannot possibly be met by the payment to him of the full amount of his titular emolument, the Council has power, if it sees fit, and if funds are available to award him an additional payment.

A candidate for a Studentship or Exhibition should apply through the principal authority of his University, and his application should reach the Senior Tutor (from whom further particulars may be obtained) by 1 May 1940.

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